INDUSTRIAL ACCIDENT PREVENTION

DAVID STEWART BEYER

SAFETY = SAVING vs. DANGER = WASTE

INDUSTRIAL ACCIDENT
PREVENTION

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PREFACE

In preparing the following material for publication, it has been the author's aim to make it an authoritative statement of accident prevention methods, proven by the "road test" of actual experience to be effective and practical. With this end in view photographs have been chosen for illustrations in preference to drawings or sketches, since a photograph which shows a device in actual use carries much more conviction than a drawing of the device, which may exist only on paper.

The broad lines of protection common to all industries are now well defined. Among these might be mentioned Building Construction and Arrangement, Power Transmission and Control, and the Safeguarding of Shop and general Mechanical and Electrical Equipment. The special hazards peculiar to certain industries have also been determined in some cases, although there are still various branches of manufacture where little safety work has been done, and in which new and interesting developments may be expected during the next few years.

The present work is devoted chiefly to a discussion of Accident Prevention proper; other subjects, however, which are related indirectly to the accident problem, such as Sanitation, Relief and Welfare Work, Hospital and First-Aid Equipment, are described in a general way.

In placing this book before the public the author wishes gratefully to acknowledge his indebtedness to the Massachusetts Employees' Insurance Association, whose Board of Directors has authorized its publication, and has permitted the use of much material from the *Safety Handbook* issued by the Association and intended solely for the use of its subscribers; in this they were guided by the belief that the information would be helpful to others working on the common accident problem, and that it would thus have a broad humanitarian value in the prevention of human suffering and accident waste.

Indebtedness is also acknowledged to the United States Steel Corporation for data and much information secured through its central Committee of Safety, and from its subsidiary companies.

Acknowledgment is also made to many others engaged in accident prevention work, who have been most generous in affording information and assistance in connection with the text and in securing suitable photographs, etc.

A number of the devices illustrated are manufactured for sale, some of them by several concerns.

The first edition of such a work is necessarily incomplete, since the Safety Movement is in a state of constant evolution. It is believed, however, that the present volume contains much information of value to those interested in Accident Prevention; any criticisms or suggestions for its improvement will be gladly received by the author.

David Stewart Beyer.

CONTENTS

PART I. GENERAL PHASES OF THE ACCIDENT PROBLEM

PART II. BUILDING CONSTRUCTION AND ARRANGEMENT

PART III. POWER GENERATION AND DISTRIBUTION

PART IV. MACHINE CONSTRUCTION AND ARRANGEMENT, ETC.

PART V. SPECIAL INDUSTRIES

PART VI. FIRE HAZARD (*see also* PART II)

PART VII. EXPLOSION HAZARD

PART VIII. PERSONAL ELEMENTS

INDUSTRIAL ACCIDENT PREVENTION

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CHAPTER I

COMPENSATION LEGISLATION

ACCIDENT COMPENSATION bears a marked relationship to Accident Prevention. Wherever Compensation Acts have been passed, making payment in case of injury a certainty, one result has been the stimulation of interest in preventing injuries. This book is devoted primarily to Accident Prevention; the following brief comments on Compensation Legislation are included, however, in the belief that a general knowledge of the latter will be helpful to anyone who is interested in the former.

HISTORICAL

For many years the United States was conspicuous among civilized nations, in having made no provision for compensating its injured workmen.* Even now a large percentage of the Government employees are not permitted to share in the meagre plan which was put into force in 1908.† In fact, these employees are in a worse position than those of a private concern, since they cannot bring suit for damages under their common law rights; the antique theory that "the king" (in other words, the accepted form of government) "can do no wrong," works thus to their disadvantage in this modern day and under our democratic form of government. In about half the States of the Union, the old "common law" usage, which leaves the redress for an industrial accident to the chances of a lawsuit, still prevails.

In recent years, however, the compensation problem has been receiving much consideration, both by the National Government and by the various States; as a result, rapid progress is being made in bringing about improved conditions.

The first comprehensive Workmen's Compensation Act in this country was passed by the State of New York in 1910;‡ it was largely an experiment, and was soon declared unconstitutional by the courts. During the succeeding four years, twenty-four States passed Workmen's Compensation Acts which are now in effect. These States are Arizona, California, Connecticut, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New York, Ohio, Oregon, Rhode Island, Texas, Washington, West Virginia, and Wisconsin. No attempt will be made here to give a complete statement of these acts, but the underlying principles which they involve, and some of their main provisions, are as follows:—

UNDERLYING PRINCIPLES

There is considerable variation in the details of these schemes. Profiting by the experience of New York, they are generally made elective in order to avoid constitutional difficulties. The arrangement is such, however, as to bring pressure upon the employer who refuses to come under the provisions of the act, through the withdrawal of his common law defences; thus most employers voluntarily elect to accept the compensation plan, without the necessity for making this acceptance legally compulsory.

* The first Compensation Act drafted along modern lines was passed by Germany in 1884; other European countries have enacted Compensation laws as follows:— Austria, 1887; Norway, 1894; Great Britain, 1897; France, 1898; Italy, 1898; Denmark, 1898; Spain, 1900; Sweden, 1901; Russia, 1903; Belgium, 1903. (See Bulletin No. 74 of the U.S. Bureau of Labor, Jan., 1908.)

† See "American Labor Legislation Review," Dec., 1914.

‡ A limited plan, including coal and clay mining in two counties, was enacted by Maryland in 1910, effective May 1st,— or four months prior to the New York Act.

The Three "Common Law" Defences

These defences date back some sixty years or more, having grown up from precedents set by the English courts and followed in this country. Meanwhile, conditions have undergone radical changes through the general introduction of machinery and the extensive organization of industrial management, so that the original principles are no longer fairly applicable.

The "Three Defences" are as follows: —

1. "Assumption of Risk"; this assumes that the employee knew, at the time of employment, that his work was to be dangerous, and that he agreed to accept this risk in consideration of the wages he received.
2. "Contributory Negligence"; that is, it was partly the workman's own fault that the accident occurred, and the employer should not be held responsible for it.
3. "Fellow-Servant" rule; that it was the fault of a fellow-employee, and again the employer should not be held for the accident.

These defences have been instrumental, in the past, in depriving injured employees of any remuneration in a large percentage of cases, even though many of the accidents occurred through no fault of the employees.* On the other hand, in order to recover damages it was necessary for the employee to show that the employer was at fault, in failing to provide some safeguard required by law, in not furnishing him a safe place in which to work, or in failure to warn him of dangers that were not obvious.

Fault

Thus, under the old common law, it will be seen that the right of a workman to receive compensation for injury was based almost entirely on the question of "fault"; — that of the employer, of the injured man himself, or of one of his fellow-employees.

As a matter of fact, very few accidents occur where there is not a certain element of fault or carelessness on the part of some one, and the injured man is usually more or less to blame; such carelessness, however, is of an inevitable sort, and might be compared to upsetting a cup of tea at the breakfast table. This involves carelessness, but such carelessness is an unavoidable characteristic of our human makeup. Where men are working around machinery to which the human body offers practically no resistance, a slip or mis-move, insignificant in itself, may prove disastrous.

In recognition of this human imperfection, and of the fact that many accidents are unpreventable and the inevitable by-product of industry, the old doctrine of "fault" is giving way to

The New Principle of Compensation

The modern idea of industrial accidents is that they should be charged to the cost of production, just as any other item of "producing" expense, and that the consumer — in other words, the man for whom the work is being done — should bear this charge.

In turning out a ton of steel, or in making a shoe, a certain amount of material is spoiled. Machinery is broken, and new equipment must be added at frequent intervals to replace that which has become worn out or obsolete. The attitude towards accidents is that there should be a charge for the repair and replacement of "producing labor," just as there is a charge for the repair and replacement of "producing equipment."

Every so often a belt or shaft breaks, the cylinder head of an engine is blown out, or a fly-wheel is wrecked; such an accident may involve a property loss of hundreds or thousands of dollars, but we would not attempt to charge up this loss to the engineer, even though greater care or thoughtfulness on his part might have prevented the accident.

This, however, is a fair parallel of what has been done commonly in the past, where the human machine was broken instead of the mechanical one; — the injured man or his immediate family has had to bear the entire loss,

* See "Report to the New York Legislature," by the Wainwright Commission, March 19, 1910.

which was often equivalent to hundreds or thousands of dollars. Such a loss is not covered by the ordinary daily wages of a workman, and careful analyses of wages in comparison with cost of living have shown that, in general, they allow no adequate margin above bare living expenses for insurance or other provision against accidents.*

The new idea of compensation is to substitute for the old hap-hazard method based on "fault," a fair, uniform charge for all industrial accidents except those caused by the "serious and wilful misconduct" of the injured man himself (drunkenness, self-inflicted injuries, etc., being specified in some statutes). While there is much variation in the plans adopted by different States, this is the underlying principle which dominates them all, and the advantages of this principle as compared with the old doctrine of "fault" might be summarized as follows: —

Advantages of the Compensation Principle

It is better for the employee because: —

(1) He is sure of receiving compensation in all legitimate cases.

(2) The delays and expenses incident to collecting damages through the courts are eliminated, payments being made promptly after the accident, at the time when they are most needed.

(3) More emphasis is placed on the prevention of accidents.

It is better for the employer because: —

(1) He can count on certain fixed charges against his business, and make provision for them.

(2) He is relieved of the trouble and annoyance of lawsuits, and the possibility of excessive verdicts which juries are liable to render.

It is better for both employer and employee because: —

(1) The money which the employer pays out goes direct to the employee, with the minimum amount of waste for "overhead charges," legal expenses, etc., which, under the old plan, ate up as much as sixty-five per cent of the total, leaving only about one-third for the injured employees.†

(2) It promotes good-will between employer and employee, through the substitution of a fair and reasonable arrangement for the former contest in which each said to the other, "It was your fault."

PROVISIONS OF THE NEW COMPENSATION ACTS

Some of the principal provisions of the new compensation acts are as follows: —

Amount of Compensation

The medical and hospital expenses of injured employees are usually paid for a certain period, and fixed amounts of compensation are allowed for various specified injuries. These amounts are commonly based on a percentage of the injured person's weekly wages. For permanent disability this percentage ranges from 50 to 66⅔, in most States with a maximum payment of three thousand to five thousand dollars, but in some States continues for life.

Payments in death cases vary from one hundred dollars for funeral expenses, where the deceased leaves no dependents, to the maximum mentioned above. In some States these payments are proportioned to the number of people dependent on the injured person for support (children, wife, husband, parents, etc.).

Security of Payments

Different provisions are adopted by the various States for assuring the payment of compensation awards. Insurance in authorized liability companies is permitted in all but four or five States. In several cases mutual associations of manufacturers have been established; also State funds managed by the Accident Board. A number of States allow employers to maintain their own fund, under supervision of the Accident Board.

Some positive arrangement is needed to

* See "Work-accidents and the Law," Eastman, Chapter 8, Page 130.

† See Report to N.Y. Legislature, by Wainwright Comm., Mar. 1910.

make sure that the injured workman will receive the specified compensation payments. Unless insurance is carried, he may lose out, through the insolvency of the employer, in case a serious catastrophe occurs.

The Waiting Period

A waiting period of from one to two weeks after the injury occurs is usually allowed, before compensation begins. The object of this is to avoid the necessity of compensating the vast number of minor injuries, and to prevent "malingering" —that is, persons who are only slightly injured prolonging the period of disability for the sake of receiving compensation payments. In several States payment reverts to the first day in case of serious injuries where disability lasts for several weeks.

Supervision

General supervision of the working of the act, with considerable discretionary power, is usually given to an Industrial Accident Board. These Boards pass upon disputed claims, appeal to the courts being available only as a last resort. In this way much delay and controversy are eliminated.

RESULTS OF THE COMPENSATION LAWS

While the compensation laws have been in effect for only two or three years at the present time (1915), it is already apparent that the desired objects are being achieved. Lawsuits have been practically eliminated in the Compensation States. Payments to injured men are being made promptly, and better relations are being established between employer and employee.

Effect of Compensation Laws on Accident Prevention

One of the important objects back of this legislation is to stimulate interest in the prevention of accidents; this is recognized, in some form or other, in most of the laws. For instance, the Massachusetts Compensation Act is entitled "An Act Relative to Payments of Employees for Personal Injuries Received in the Course of their Employment and *to the Prevention of Such Injuries*"; it requires the Board of Directors of the Massachusetts Employees Insurance Association (a mutual Compensation company created by the act) to "make and enforce reasonable rules and regulations for the prevention of injuries on the premises of subscribers."

Aside from the question of legal responsibility, however, compensation acts provide a further stimulus in accident prevention for the following reasons: — *First*, the certainty that accidents will require compensation payments, and that the employer cannot evade this responsibility. *Second*, the fact that the new compensation laws immediately resulted in a material increase in the premium which an employer paid to insure his workmen against accidents. In some cases the new insurance rates were several times as high as the old ones. Thus the insurance premium immediately became a serious item of cost, which it behooved each employer to consider carefully with a view to its reduction.

That this increased cost *is* stimulating accident prevention is very evident in the States having compensation legislation. The matter has been brought home forcibly to the employer, and to ordinary humanitarian motives has been added the realization that the prevention of accidents is the only effective method for reducing the high cost of insurance.

From any standpoint, an accident prevented is better than an accident compensated. The best standard by which to judge the value of a compensation plan is its effect in reducing accidents; other things being equal, that plan will most surely fulfill the spirit of the age, and give the highest factor of efficiency, which places the greatest emphasis on the rational application of preventive measures.

CHAPTER 2

ACCIDENT WASTE *vs.* ACCIDENT PREVENTION

ACCIDENT WASTE

MASSACHUSETTS is recognized as one of the important industrial states of the Union. Its industries, however, are largely of a light and relatively non-hazardous character such as the manufacture of shoes, textile goods, jewelry, and the construction of small machinery of various kinds; it has none of the hazards of coal mining, and few of those involved in heavy iron or steel work; yet during the year ending June 30, 1913 (the first after the Workmen's Compensation Act went into effect) there were reported to the Industrial Accident Board 90,168* accidents, 474 of which were fatal. (See Chapter 3.)

After a comprehensive study of industrial accidents in 1908, the Department of Commerce and Labor estimated that there are from 30,000 to 35,000 fatal, and not less than 2,000,000 non-fatal accidents in the United States every year.

It is impossible to conceive the suffering involved in this vast aggregate of figures, each unit of which means distress to an individual, and in many cases disaster to an entire family. Our humanitarian instinct should give the strongest possible incentive for the adoption of safety measures; there is still another important incentive, however, and that is the economic value of such measures.

The ninety thousand accidents which occurred during a year in Massachusetts caused 1,156,787 days lost time; this is equivalent to 3,855 persons being constantly disabled. The cost to employees, through loss in wages alone, was $2,965,225.00, or about $10,000.00 for each working day of the year. The cost to employers, in compensation premiums alone, was approximately $4,000,000.00. (See First Annual Report of the Massachusetts Industrial Accident Board.)

Add to these items incidental accident expenses due to loss of product, disorganization of working forces, the cost of maintaining hospitals and other charitable institutions for injured workmen, the care of dependent families† whose wage earners are incapacitated by accidents, and the total for the United States may well run into the hundreds of millions of dollars per annum.

Owing to the lack of adequate statistics for the entire country, exact estimates are impossible, but this will give some idea of the seriousness of the accident problem from the economic standpoint. Realizing the need of accurate statistical information, many of the states are making arrangements to see that accidents are carefully reported and compiled, so that conclusive figures should be available before long.‡

When it becomes generally known that at a conservative estimate, at least 50% of all industrial accidents are preventable, and the resultant waste in men and dollars can be stopped,

* 21,108, or 24% of these accidents, incapacitated the injured employee for more than two weeks; of the remainder, 31,685, or 35% of the total, involved more than one day's incapacity each. The non-fatal accidents caused the loss of both eyes in 2 cases; one eye in 47 cases; both feet in 1 case; one foot in 22 cases; one hand in 35 cases; two or more fingers in 133 cases; one finger in 672 cases; two or more toes in 21 cases; one toe in 34 cases. 770 persons were wholly dependent, and 103 partially dependent, on the 474 employees who were fatally injured.

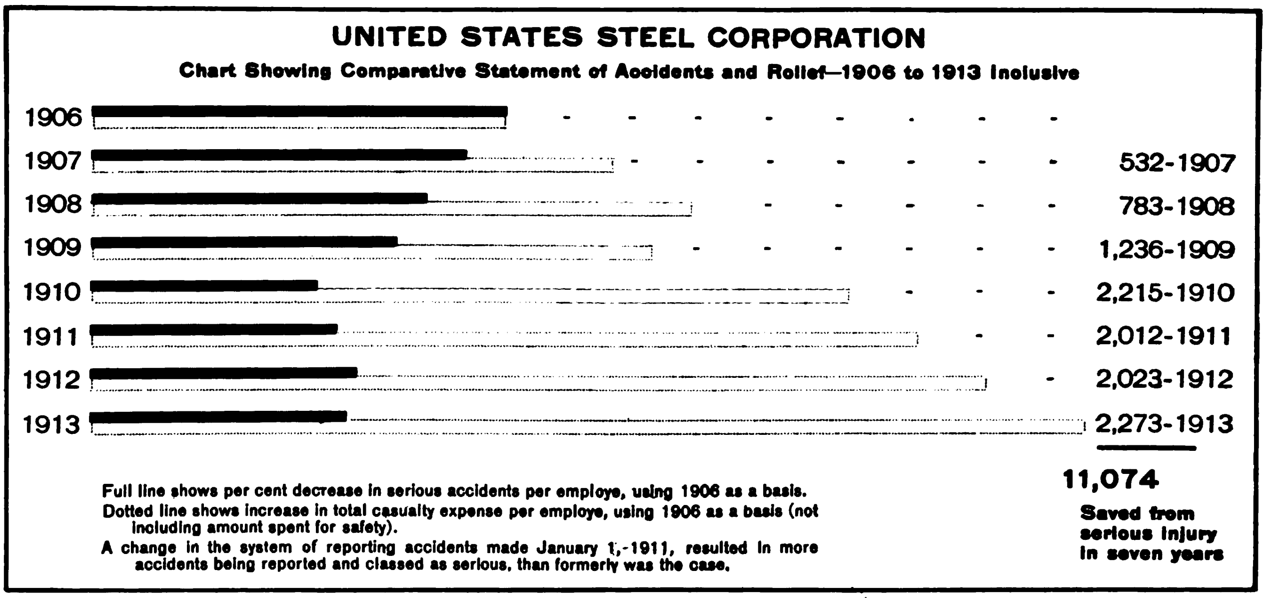
† In an article published in the "The Survey" September 3, 1910, Miss F. L. Lattimore states that an investigation of the 3,000 boys and girls in the various homes and children's institutions of the Pittsburg district, shows that approximately 15% are there as the result of industrial accidents and trade diseases. How many more are spending their days in shops and offices instead of under normal home and school influences cannot be even approximated.

‡ Much valuable work in this direction has been done by the American Association for Labor Legislation; it has drafted standard bills and forms for reporting industrial accidents, and is endeavoring to secure uniformity in these matters among the various states.

public sentiment will do the rest. That the condition is being recognized, and that active steps are being taken to improve it, is apparent from the growing interest in Accident Prevention which is manifesting itself all over the country. This interest is finding expression not only in the efforts of individual industrial concerns, but also in organized movements among associations of manufacturers, etc., as well as in the establishment of new and higher legislative standards.

Systematic and thorough-going efforts in accident prevention in this country date back only about ten or twelve years. In that time, however, a number of progressive industrial organizations have demonstrated beyond a doubt the possibilities of such work. The following information, taken from various lines of industry, shows conclusively that accidents *can* be prevented.

Take for example the United States Steel Corporation, which was a pioneer in such work



ACCIDENT PREVENTION

In a small plant having only a few accidents per year, a comparison of one year's record with that of another does not indicate conclusively the results of accident prevention work. Purely accidental variation may make the record better or worse from year to year, without any other cause. Several serious accidents may occur at about the same time, and many years elapse before there is another such combination.

It accordingly follows that statistical data on the reduction of accidents, in order to carry conviction, should cover a considerable number of employees and extend over a period of years.*

in this country. Its experience, covering approximately 200,000 employees, is shown in the accompanying chart.

This chart indicates a maximum accident reduction of 43% from the record of 1906. It is noteworthy that during the seven-year period, *more than 11,000 persons were saved from serious injury.*

The increase in casualty expense, as shown by the dotted lines, is explained by the fact that the Corporation has made more and more liberal payments to its injured workmen, until in 1910 it adopted a voluntary compensation

* See "How extensive a payroll exposure is necessary to give a dependable pure premium," Albert H. Mowbray, Proceedings of the Actuarial and Statistical Society of America, Vol. 1, No. 1, Nov. 7, 1914. The conclusion of this paper seems to be that on the average, not less than 10,000 employee-years must be observed in order that the accidental variations may not be so large as to render the experience undependable for insurance purposes.

scheme similar to those since passed by a number of States.

During this period, several millions of dollars were expended for the installation of safety devices. The saving in compensation expense effected by the prevention of accidents, however, shows a large return on even this enormous expenditure, indicating that the Corporation's safety campaign has amply justified itself from the financial, as well as the humanitarian, standpoint.*

REMINGTON TYPEWRITER WORKS

Summary of accidents for five years ending December 31st, 1911:—

Year	*Average Number Employees*	*Average Number Machines*	*Accidents from Machinery*	*Other Accidents*	*Accidents of all Kinds*
1907	1500	1364	23.3	22.0	45.3
1908	1650	1407	20.0	18.1	38.1
1909	1900	1470	15.8	13.7	29.5
1910	2200	1525	14.1	11.3	25.4
1911	2500	1700	13.2	11.2	24.4

This plant, located at Ilion, New York, includes brass and iron foundries, annealing and hardening departments and a variety of wood and metal working machines, etc. About 20% of the employees are women.

During the five-year period included above, the number of employees *increased 66%*, the number of machines *increased 25%*, and accidents of all kinds per thousand employees, *decreased 46%*. (See "Human Engineering," April, 1912.)

CHICAGO & NORTHWESTERN RAILWAY COMPANY

Accidents to Employees

The following table gives the experience of this company for the past five years, with the percentage reduction in accidents for each year as compared with the year 1910:—

Year	*Killed*	*Reduction*	*Injured*	*Reduction*
1910........	97	—	8404	—
1911........	76	22%	6025	28%
1912........	73	25%	6043	28%
1913........	67	31%	6395	24%
1914........	49	39%	5520	34%

The decrease of 39% in fatal injuries and 34% in non-fatal injuries for the year 1914 was effected notwithstanding the fact that the mileage for this year was approximately 6% greater than that for the year 1910.

The four and one-half years ending December 31st, 1914, compared on an equal basis with the year first considered, show a total of *173 fewer employees killed* and *10,671 fewer employees injured.*

Accidents to Passengers

The effectiveness of an accident prevention and educational campaign in preventing railway accidents to the public, is also shown by the experience of this company. The four and one-half year period mentioned above, compared with the year first considered, shows a decrease of 961 passengers injured, 210 outsiders killed, and 228 outsiders injured. During the four and one-half year period, two passengers were killed compared with none during the first year; these fatalities, however, resulted from carelessness on the part of the injured persons in jumping off trains, etc., and not to train accidents. A large net saving in the public accidents is apparent from this data.

EASTMAN KODAK COMPANY

Machine Accidents

SUMMARY OF ACCIDENTS AT THE FIVE ROCHESTER FACTORIES FOR THE YEARS 1910, 1911, 1912, 1913, AND 1914.

(Average number of employees, about 5,000.)

	1910	*1911*	*1912*	*1913*	*1914*
Fingers and hands between punch presses and shears..	54	40	24	29	18
Fingers and hands against woodworking saws.......	18	19	15	11	6
Fingers and hands into woodworking cutters.........	8	10	7	8	3
Injured around elevators...	3	5	4	4	1
Injured around emery and other grinding wheels....	11	4	9	9	6

* Bulletin No. 5 of the United States Steel Corporation (Dec., 1914) states that the expenditures for safety for the three-year period 1911–1913 inclusive, amounted to $2,003,-712.29, or an average of approximately $668,000.00 per year. The estimated gross saving in casualty expense for the same period is given at $4,775,692.64, or approximately $1,600,000.00 per year. Assuming that the expenditures for safety were maintained throughout the eight years shown in the above chart, at the same rate, the total would be $5,328,000.00. The saving in casualty expense of $1,600,000.00 per year would give a return of 30% on this investment.

	1910	1911	1912	1913	1914
Fingers and hands under drilling and boring machines..	32	8	19	4	3
Fingers and hands into aut. screw machines.........	4	3	5	6	—
Injured around lathes and milling machines........	18	2	4	7	6
Injured on machines of special nature..............	4	2	12	13	8
Total..............	152	93	99	91	51
Number of Machine Accidents per 1000 Employees..............	40	22	18	15	9
Percentage reduction compared with year 1910...	—	47%	56%	63%	78%

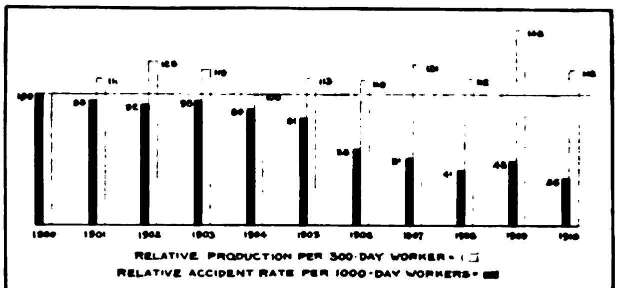
General Accidents

Bruises, burns, lacerations, and injuries of minor importance...............	166	144	156	133	64
Falling off ladders, platforms, etc., and slipping........	41	27	36	54	26
Obstructions in passageways and doorways...........	2	2	7	11	7
Falling tools, material, etc...	36	32	26	37	8
Stepping on nails..........	15	11	17	12	2
Total..............	260	216	242	247	107
Number of General Accidents per 1000 Employees..............	69	50	43	40	19
Percentage reduction compared with year 1910...	—	28%	37%	42%	73%
Total Accidents per 1000 Employees...........	110	72	61	55	27
Percentage Reduction of Total Accidents	—	35%	44%	50%	75%

STEEL WORKS

The accompanying chart, which shows the experience of a large steel works having ten years' consecutive accident record available, is of particular interest. It will be noted that during years of high production, the accidents per thousand employees tended to increase. This shows the effect of taking on new men and working under higher pressure.

The changes from year to year were slight,



RELATIVE ACCIDENT RATES AND PRODUCTION IN LARGE STEEL PLANT INVESTIGATED, BY YEARS, 1900 TO 1910

indicating that progress was gradual. The maximum reduction of accidents cannot be expected within a year or two. The ten years' experience of this company, however, shows that *64% of the accidents have been eliminated*, compared with the record for 1900.

The experience of many other companies, such as the International Harvester Company, Pennsylvania Railroad Company, the New York Central Railroad Company, the Cadillac Motor Company, the Milwaukee Gas and Coke Company, the Norton Company, the General Electric Company, the Ludlow Manufacturing Associates, and the Boston Elevated Railway Company might be cited in corroboration of the statement that accidents *can be prevented*. The list of such companies is large and it is constantly growing larger. The American manufacturer, from Massachusetts to California, has taken hold of accident prevention work with vigor and enthusiasm, as soon as its possibilities were clearly demonstrated to him.

CHAPTER 3

CAUSES OF ACCIDENTS

A GOOD general idea of the causes of industrial accidents may be obtained from the following list of approximately 90,000 injuries, which occurred in Massachusetts during one year. (See First Annual Report of the Industrial Accident Board, for year ending June 30, 1913.)

	Fatal	Non-Fatal
ACCIDENTS caused by machinery peculiar to Special Industries	***7***	***11,375***
Cotton Mills	0	2,196
Shoes	1	1,588
Woolen and Worsted Mills	1	981
Miscellaneous Textiles, — Knitting, Linen, etc.	0	655
Foundries and Metal Working	0	617
Miscellaneous Iron and Steel Workers	0	465
Miscellaneous Metal Workers	0	461
Paper and Pulp Mills	0	457
Woodworking, Boxes, Furniture, Planing Mills, etc.	1	454
Clothing, Gloves, Hat, and Shirt Makers, etc.	0	309
Rubber Factories	0	290
Electrical Supplies	0	276
Tanneries	1	226
Knitting Mills	0	209
Printing and Publishing Establishments	0	180
Wholesale and Retail Trade	0	178
Carpet Mills	1	146
Building and Hand Trades	0	109
Miscellaneous	2	1,787
ANIMALS, INSECTS, etc., — Bite, Kick, Sting, etc.	***9***	***779***
ASPHYXIATION, DROWNING, IMMERSION, etc	***10***	***91***
ASSAULT and FIGHTING	***1***	***207***
BELTING:	***6***	***888***
Shifting by stick or hand, etc.	2	196
Caught between belt and pulley (not while shifting)	2	207
Contact with running belt (not while shifting)	2	265
Hooks or fasteners (not while shifting)	0	71
Struck by breaking belt	0	110
Replacing belt with stick	0	39
BOILERS and STEAM EXPLOSIONS	***1***	***36***

	Fatal	Non-Fatal
BURNS:	***14***	***3,319***
Chemical	0	274
Fire	6	378
Hot objects	0	736
Molten metal	0	811
Steam, hot liquids, etc.	8	1,120
CALENDERS	***0***	***103***
CRANES:	***11***	***306***
Breaking cable or chain	4	17
Breaking hook	0	14
Caught in moving parts	2	158
Struck by load	3	108
Struck on runway by moving crane	2	9
DRILLS and DRILL PRESSES	***0***	***425***
ELECTRICITY:	***25***	***495***
Flashes and short circuits	3	207
Shocks	20	149
Other generator and motor accidents	2	139
ELEVATORS:	***33***	***1,036***
Caught in machinery	0	45
Caught between car and shaft	11	273
Caught underneath or on top of car	3	53
Falling car	3	39
Falling down shaft (person)	5	72
Struck by falling object	0	30
Caught by fire hatch or trap	2	11
Miscellaneous	9	513
EMERY WHEELS:	***2***	***650***
Bursting	2	47
Cuts and abrasions	0	603
ENGINES:	***0***	***113***
Caught in or struck by moving part	0	110
Fly-wheel bursting	0	3
EXCAVATING:	***14***	***164***
Blasting and drilling	0	15
Cave-in	14	143
Miscellaneous	0	6
EXPLOSIONS (other than Boilers)	***4***	***215***
EXTRACTORS (Centrifugal)	***0***	***11***
EYE INJURIES:	***0***	***4,331***
Belting	0	9
Chemicals	0	217
Electric flash	0	45
Emery wheels	0	1,151
Flying particles from hand tools	0	511
Lubricator and gage glasses	0	8
Machine tools (including portable tools)	0	57
Molten metal	0	120
Miscellaneous	0	2,213

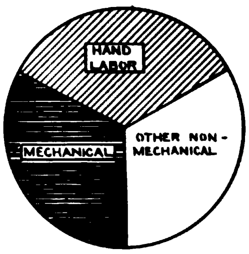
	Fatal	Non-Fatal
FALLING MATERIAL from overhead	***8***	***1,664***
FALLS:	***66***	***8,417***
From fixed ladders	0	19
Into holes, pits, etc.	1	459
Over obstructions	0	481
From permanent structures	4	162
From poles	0	60
From or with portable ladders	6	802
From scaffolding, etc.	16	780
Slipping on floor level	0	1,385
Down stairways	1	859
Miscellaneous	38	3,410
GEARS	***2***	***1,101***
GLASS:	***1***	***1,281***
Bottles and miscellaneous	1	905
Windows	0	376
HAND LABOR:	***37***	***29,737***
Caught by material	30	12,632
Flying particles from hammering tools	0	539
Slivers, sharp edges, corners, etc.	1	11,641
Strains from lifting, etc.	5	1,832
Struck by tools	1	3,093
HOISTS:	***4***	***630***
Breaking parts	1	77
Falling loads	0	147
Miscellaneous	3	406
ILLNESS	***3***	***290***
INFECTION from trivial cuts, burns, etc.	***5***	***2,102***
INTOXICATION	***0***	***56***
LATHES:	***0***	***767***
Woodworking	0	69
Metal working	0	698
MILLING MACHINES	***0***	***181***
MISCELLANEOUS (Unclassified)	***11***	***5,149***
NAILS:	***0***	***3,462***
In boxes, barrels, or objects	0	1,643
On floor or ground	0	1,819
PLANERS (metal)	***0***	***73***
PLAYING and FOOLING	***0***	***81***
PORTABLE TOOLS (other than rock drills)	***0***	***10***
PRINTING PRESSES	***1***	***193***
PUNCH and DROP PRESSES, and miscellaneous Presses	***1***	***1,139***
RAILROAD EQUIPMENT:	***119***	***1,230***
Caught in frogs, switches, etc.	0	27
Coupling or uncoupling cars	8	107
Falls from cars or locomotives	7	282
Falls from trestles	1	7
Hoisting and conveying outfits	0	2
Struck or run over by car or locomotive	78	188
Collisions	10	134
Miscellaneous	15	483

	Fatal	Non-Fatal
SAWS	***4***	***1,579***
SHAFTING, SET-SCREWS, COUPLINGS, etc.	***9***	***481***
VEHICLES:	***43***	***3,770***
Animal-drawn	33	1,704
Self-propelled	8	545
Trucks, wheelbarrows, etc.	2	1,521
WOOD MOULDERS, SHAPERS, MORTISING MACHINES, etc.	***1***	***351***
STREET RAILWAYS:	***20***	***1,302***
Caught between cars (other than while coupling)	3	24
Caught between car and fixture	0	8
Collisions between cars	2	92
Collisions between car and vehicle	4	160
Coupling cars	1	11
Detrailment	0	10
Falls from cars (other than off running boards)	1	88
Frogs, guardrails, switches, etc. (foot caught)	0	13
Line work, tower apparatus	0	7
Pit room accidents	1	30
Running boards (lost hold)	0	93
Running boards (struck by object)	1	114
Struck or run over by car	6	93
Track work, handling rails, etc.	0	148
Miscellaneous	1	411
OCCUPATIONAL DISEASES:	***2***	***104***
Anthrax	1	13
Lead Poisoning	0	12
Arsenic Poisoning	0	2
Miscellaneous	1	77
TOTAL	***474***	***89,694***

This list is fairly characteristic of any industrial State, except as regards the "Accidents caused by machinery peculiar to Special Industries." These accidents vary in accordance with the different industries represented. As might be anticipated from the large number of textile plants in Massachusetts, textile machinery heads the list of such accidents in the above table, with a total of 3,833 injuries. These injuries were caused by pickers, cards, lap machines, spinning, weaving, and knitting machines, etc. The detailed hazards of these, and various other special machines, are discussed in later chapters.

PROPORTION OF MECHANICAL ACCIDENTS

An analysis of the above list of accidents to determine what percentage of the total is mechanical, gives the following results: —



	NON-FATAL	FATAL
MECHANICAL	32,088	215
HAND LABOR	29,737	37
OTHER NON-MECHANICAL	27,869	222
TOTAL	89.694	474
GRAND TOTAL	90,168.	

It will be noted that approximately one third are mechanical (that is, they occurred on machines, shafting, gearing, etc.) and the other two thirds are non-mechanical. The latter are divided about equally between hand labor (injuries while lifting or handling material, using hand tools, etc.) and other non-mechanical injuries such as slipping, falling, vehicles and occupational diseases.

While the mechanical accidents are about equal, numerically, to those caused by hand labor, they were responsible for 215 fatalities, compared with 37 fatalities from hand labor. In general it can be said that mechanical accidents are more severe than non-mechanical accidents, due to the force exerted by power-driven machines. To be caught in the gearing or other moving parts of a machine usually means severe laceration; it frequently results in the loss of hands or other parts, involving partial or total disability.

This analysis, and other data of a similar nature investigated by the author, leads him to conclude that from the standpoint of seriousness, industrial accidents are divided about equally between mechanical and non-mechanical causes. In a given plant, the proportion varies according to the nature of the industry and the amount of safety work which has been done. The above statement, however, is fairly representative of present conditions throughout the average manufacturing State.

This conclusion has an important bearing on the lines of effort to be adopted for the prevention of accidents. It indicates that after all possible mechanical safeguards have been installed, there will still remain a large percentage of accidents which cannot be prevented by mechanical means. There is an effective way to reach such accidents, however, which is equally important with the installation of mechanical safeguards; that is the *education* of the workmen in the exercise of greater care for the avoidance of injuries to themselves and their fellow-workmen. For methods of education, involving the use of Safety Committees, Bulletins, Signs and Slogans, etc., see Part VIII.

To summarize, — we may conclude from the results of this and the previous Chapter, that 50% of our present industrial accidents are preventable, — 25% by Mechanical Safeguards, and 25% by Education.

CHAPTER 4

ENGINEERING PROVISIONS

MUCH responsibility is placed upon the modern engineer for efficiency in construction and operation. One of his principal duties is to eliminate needless expense or waste. In the pursuance of this duty, familiarity with improved safety practice and ability to apply it to his current work are essential.

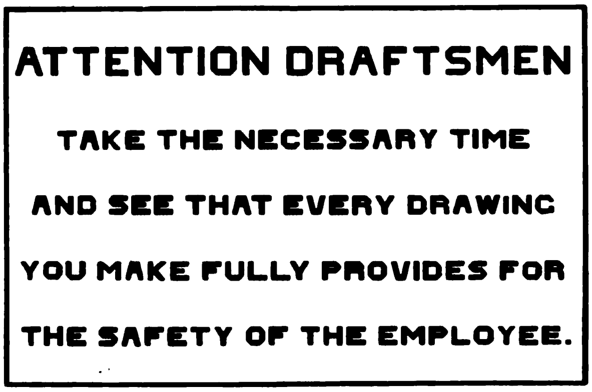


Fig. 1. Safety Sign for Drafting-Rooms.* Size 3' x 4'.

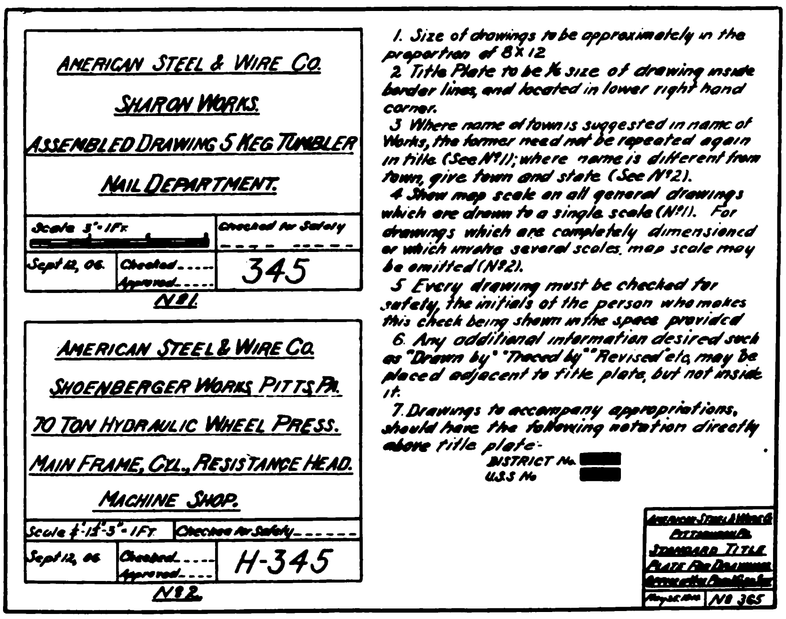


Fig. 2. Standard Title Plate with "Checked for Safety" Clause.*

Practically all new construction and changes of any importance, pass through the hands of the engineer, so he is in a peculiarly favorable position to secure the adoption of proper safety measures at the outset.

THE DRAFTING-ROOM

When a new plant is being built, or when an addition to an old plant or its equipment is being made, safeguards can be obtained with the minimum of trouble and expense. They can then be provided for in the drafting-room, while the installation exists only on paper. It is expensive to make changes after the equipment has been constructed and placed in service.

At the time of repairs or alterations to machinery and equipment already in place, it is often possible to provide safety devices at little or no expense, which would involve a large expenditure if put in separately.

Where engineers or draftsmen are permanently employed at a plant, this phase of their work should be strongly impressed upon them. In order to keep it always fresh in mind, a sign such as that illustrated in Fig. 1 may be posted, to advantage, in the drafting-room.

The "Title Plate" shown in Fig. 2 has been adopted by a large industrial concern as a standard arrangement to be placed on all of its construction and repair drawings; Rule No. 5 requires every drawing to be "checked for safety" before it is sent out. This insures proper safety provisions being made before any work is done from the drawing.

* Courtesy American Steel and Wire Company, subsidiary United States Steel Corporation.

SPECIFICATIONS

New machinery is being installed constantly in mills and factories, in an unprotected state, merely for the lack of definite specifications calling for proper safeguards at the time the machinery is ordered. Many manufacturers have patterns for gear guards, etc., which they will furnish with their machines if requested to do so, but otherwise will omit.

Machinery is commonly purchased on a competitive basis, the lowest bid determining who shall get the order; this furnishes a strong incentive to build at the lowest possible cost, and one way to lower the cost is to leave off safeguards. Thus the progressive machinery manufacturer, who would like to protect his equipment in a first-class manner, is frequently handicapped by the low standard set by his competitors, who are satisfied to build cheaply at the expense of safety.

Machine safeguards can be furnished at the least outlay by the manufacturer of the machine, who can distribute the cost of patterns, etc., over a number of machines. He can also make the safeguards an integral part of the design, so as to secure the best results from the standpoint of appearance and convenience in arrangement.

Where a machine is installed without protection, the situation is unfortunate for several reasons; if guards are provided by the purchaser, it is often difficult to adapt them to a machine which was not arranged for them in the beginning; furthermore, the local mechanical forces are usually limited in number, and so occupied with their current duties that it is hard to find time for extra work of this sort; where they do make up guards, the latter are likely to be unsightly and unsatisfactory, unless given considerable thought and attention by a man especially skilled in this line of work. Worst of all, — some one is liable to be seriously injured before the guards are installed.

The solution of the whole difficulty lies in the use of proper specifications. This is of value to the manufacturer of machinery as well as to the purchaser, since it tends to put all bids on a parity; in submitting a quotation, the manufacturer knows that all competitors must figure on the same equipment. On behalf of the machinery builders, it can be said that most of them are entirely willing to co-operate in this work; in fact, they have adopted many precautions on their own initiative, in spite of the competitive conditions mentioned above. A good example of this is furnished by the familiar types of machine tools; one need only compare modern machines with those built a few years ago, to note a radical improvement in safety features.

The most common lack in machinery of this sort is gear guards. Projecting set screws, unprotected couplings, etc., are also encountered. The adoption of a simple clause such as the following, which is applicable to all machinery, would prevent much trouble and avoid numerous accidents, if used as a general specification whenever new equipment is being ordered: —

"*All gearing shall be completely enclosed with substantial cast-iron or sheet-steel covers, so designed as to make the machine parts readily accessible; all couplings, set screws, keys, bolts, etc., in revolving parts, must be countersunk or covered in such a way as to eliminate danger of accident; unused portion of keyways to be filled so as to present a smooth surface.*"

The adoption of such specifications is strongly urged; complete safety specifications for various types of equipment, such as boilers, engines, cranes, machine tools, etc., will be found elsewhere in this volume, under their respective subject-headings.

CHAPTER 5

PLANT ARRANGEMENT

SUPERIOR safety conditions are secured where the factory site contains ample ground, so that the buildings need not be crowded in relation to one another, and so that one-story, or at most two-story buildings can be used. Fire hazard, building collapse, and inadequate lighting are readily avoided in the case of one-story buildings, but become more and more difficult to guard against as buildings increase in height, and as the space between buildings decreases.

This, of course, is only one of many considerations in selecting a factory site, but it should not be overlooked. It puts a considerable premium, from the safety standpoint, on suburban or country sites for manufacturing plants, as compared with congested city districts; other things being equal, this advantage would justify the selection of the former location in preference to the latter.

In laying out a new factory or manufacturing plant, there are several important safety features to be kept in mind. The building location and arrangement should be such as to minimize danger from Explosions, Fire Exposure, and Inadequate Light. Suitable provision should be made for Safe Access to Plant, and Safe Yard Conditions.

LOCATION OF EXPLOSIVES

Under the head of "Explosives" may be classed steam boilers and engines, as well as powder, dynamite, gasoline, benzine, and similar substances which, under conditions commonly encountered, may cause explosions. The important consideration is to locate such equipment or materials in a position relative to occupied buildings which will minimize danger of personal injuries in case an explosion should occur.

Location of Boilers

If the explosive possibilities of steam boilers, piping and other steam apparatus were generally realized, more care would undoubtedly be used in selecting locations for such equipment. Prof. Thurston, in a paper printed in the Proceedings of the American Society of Mechanical Engineers for May, 1885, points out the fact that every cubic foot of water at a pressure of 70 lbs. per square inch, has inherent explosive energy equal to that of a pound of gunpowder, this energy increasing or decreasing as higher or lower steam pressures are used.

No one would think of locating a magazine containing several tons of powder in the midst of a crowded factory building. This, however, is a fair parallel of what is often found in connection with steam-boiler equipment. (See Fig. 3, P. 15.) The reason for this condition undoubtedly lies in the fact that serious boiler explosions are relatively infrequent. While there are several hundred in the entire country each year, they do not occur often enough in the experience of any one person to give the emphasis that comes from reiteration; it is even possible that many engineers and executive officers have never had any personal knowledge of such an accident.

Just as in the case of powder or dynamite, explosive possibilities are always present, where steam is being generated under pressure. An explosion of steam apparatus is likely to be so destructive to life and property, that every possible precaution should be taken to reduce the danger.

It sometimes happens, particularly where the power plant is small, that high-pressure boilers are located directly in workrooms, or in

Fig. 1. Subway at Plant Entrance.*

Fig. 2. Viaduct at Plant Entrance.*

Figs. 1 and 2 show provisions for guarding against accidents on railroad tracks adjacent to a plant, when the employees are entering or leaving the plant; an overhead viaduct and an underground subway. In both cases fences are arranged so as to prevent employees from crossing the tracks on the surface, as they might otherwise try to do.

Fig. 3 shows the results of a serious boiler explosion. It will be noted that adjoining buildings suffered considerable damage. This emphasizes the importance of having boiler plants isolated wherever possible, so as to minimize the injury to other buildings and their inmates in case an explosion should occur.

Fig. 3. Plant wrecked by Boiler Explosion.

Fig. 4. Car wrecked by Steam.

Fig. 4 is a picture of a railroad car which was wrecked by the sudden generation of steam, resulting from water being turned on to hot slag. It would seem almost unbelievable that such force could be developed in an open car. This illustrates the necessity for precautions in guarding against molten metal or slag being brought into contact with water in confined spaces, as mentioned in the text.

* Courtesy of American Steel and Wire Company, subsidiary of the United States Steel Corporation.

basements where persons are commonly employed directly over them. Wherever practicable the boiler equipment should be placed in a separate building, reasonably isolated from other departments of the plant, and manufacturing or other operations unrelated to the boiler plant should not be carried on within the building.

Even in the case of the small power plant, it is usually possible to locate the boilers in a separate annex, where at least the protection of a substantial brick wall will be provided for employees in other rooms. While a wall may offer no effective resistance to a genuine boiler explosion, it materially reduces the danger from flying objects, and from burns or scalds when there is a minor explosion such as a bursting steam pipe or connection. In addition, a wall may be effective in preventing a panic among employees in such cases, by preventing the free escape of steam within the workrooms.

One of the worst boiler explosions in recent years occurred at the Grover Shoe Factory, Brockton, Mass., on March 20th, 1905. As is likely to happen in such cases, the explosion was followed by a fire, a portion of the building having collapsed. As a result of the explosion and fire, 57 people lost their lives and 117 suffered injuries of various kinds. Although the boiler in this case was in a separate annex, this annex was located practically at the junction of two wings of the main building, which received the full effect of the explosion.

The immediate cause of this accident was a crack which developed in a lapped joint, where it could hardly be detected by ordinary inspection or supervision. The damage and consequent loss of life, however, would undoubtedly have been greatly reduced if the boiler plant had been isolated.

In considering the explosive possibilities of boilers it is worthy of mention that the danger is not, by any means, confined to those carrying high pressures. Accidents causing loss of life have occurred from low-pressure heating boilers, — from the hot water systems commonly used in dwelling houses, — and even from exploding peanut roasters. (See "The Locomotive," July, 1913.)

Aside from the general location of the boiler plant, there are many other important safety precautions for steam equipment which are discussed in Chapter 11.

Steam Piping

The location of high-pressure steam piping is also important, as it may be responsible for serious accidents. In laying out a new plant it is usually possible to place the steam piping in locations where a bursting part would not endanger human lives. It is particularly desirable to avoid carrying steam lines through workrooms, offices, etc. A case has come to the author's notice where the bursting of a cast iron pipe connection trapped two men in a small office, and before they could escape both were fatally scalded.

Location of Engines

All that has been said about the explosive possibilities of boilers might be reiterated in connection with engines, — or more specifically, — engine fly-wheels. Large buildings have been wrecked and many lives lost as a result of fly-wheels bursting or "exploding." (See Page 97.)

A writer in a current publication refers to one plant which has had three such accidents within the past few years. The first of these killed one person and injured three others, with a property loss estimated at $100,000.00 (including the indirect loss due to shut-down of plant); the second caused four deaths and a property loss of $50,000.00; the third involved a loss of $25,000.00.*

Such a series of catastrophes in a single plant is unusual, but it shows what *may* happen, and indicates the necessity for great care in guarding against fly-wheel accidents. To this end the location of the engine is important, aside from the question of operating precautions.

While it is not generally feasible to place the main driving engine in an entirely separate building, it can usually be isolated in a separate

* See "Fly-wheel Explosions," W. H. Boehm, Insurance Engineering, June, 1905.

room. Where practicable this room should take the form of an annex to the main building, and, as the force of a fly-wheel explosion is felt principally in line with the wheel, it is desirable to have the wheel so located that the plane of rotation does not intercept any other building.

It is well, for the same reason, to make engine rooms one story in height, so that employees will not work directly over the engine.

A fairly common form of engine accident is that in which a cylinder head is knocked out, due to a break in the connecting rod, the presence of water in the cylinder, etc. Damage, in such cases, is principally in line with the engine cylinder, and it is accordingly desirable to have passageways and doors so arranged that they are not within this line. Several fatal accidents that have come to the attention of the writer emphasize the importance of this precaution.

Further suggestions for avoiding fly-wheel accidents are given in Chapter 12.

Location of Volatile Oils

Gasoline, benzine, naphtha, carbon bisulphide and other similarly volatile and highly inflammable liquids should be stored as far from main buildings, lumber piles, etc., as conditions permit. The minimum distance should be preferably not less than fifty feet. Where it is impossible to secure this distance, the pipes for filling the tanks may be carried to a point where the unloading station will be properly isolated. The ground at the unloading station should be sloped so that oil could not reach any buildings in case an accident should occur while the storage tanks are being filled.

Storage tanks should not exceed one carload, or about ten thousand gallons capacity, each, and should be buried at least two feet below the ground level.

It should be borne in mind that the abovementioned liquids constantly give off a gas at atmospheric pressure, which will explode if mixed with the right proportion of air. This gas is heavier than air, and it tends to accumulate in any enclosed space into which it may escape, such as sewers, tanks, basements of buildings, etc.

It is accordingly important that storage tanks be located well below the floors of buildings in which the liquid is to be used, so it cannot flow into the buildings by gravity. It is inadvisable to place storage tanks in vaults, since vapor may collect and cause an explosion.

The arrangement should be such that storage tanks can be filled during daylight, without the use of artificial light.

Hazardous processes, such as naphtha cleaning, de-greasing of skins, cement mixing, gasoline engine testing, varnishing, etc., involving the use of considerable quantities of gasoline, benzine, naphtha, or other similar liquids, should preferably be located in rooms or buildings separated by an open space from other rooms or buildings containing employees not directly engaged in the hazardous process.

Where such processes are necessarily located in rooms adjoining other rooms or buildings, they should be isolated by fire walls, preferably of solid construction. If doorways in the fire walls are essential, they should be protected by standard fire doors. The rooms in which the inflammable liquids are used should be well ventilated in such a manner that the force of an explosion would be upward or outward and away from other buildings.

For further information regarding the use and handling of volatile oils, see Chapter 45. (See also rules and requirements of the National Board of Fire Underwriters.)

Location of Molten Metal

Serious explosions are sometimes caused by molten metal coming in contact with water in a confined space which does not permit free escape of steam. (See Fig. 4, P. 15.) Furnaces and receptacles for molten metal should be so located with respect to sewers, water piping, etc., as to minimize the danger of such occurrence.

Location of Miscellaneous Explosives

Where the work or processes carried on in a plant necessitate the use of miscellaneous explosives, such as gun-cotton, nitro-glycerine, dynamite, gunpowder, etc., they should be stored in such locations, and at such distances from inhabited buildings, as will reduce to the minimum the danger in case they should accidentally explode.

Barriers such as hills or artificial mounds offer considerable protection from the force of an explosion. The danger radius from such storage places, however, varies largely in proportion to the amount of explosive stored.

Many states have statutes governing the maximum quantity of explosives permitted for a given degree of isolation. Any laws or ordinances for the particular community in which such materials are to be used should, of course, be looked up and followed explicitly.

Detailed standards which are recommended for use where there is no specific legislation on the subject, are given in Chapter 42.

FIRE EXPOSURE

From the standpoint of plant arrangement, the fire hazard may be reduced by so locating buildings in relation to one another as to minimize the exposure from adjacent buildings outside the plant, as well as from those within it. Where conditions are such as to make the desired arrangement impracticable, buildings should be protected on exposed sides by fire walls; any openings in these walls should have fire doors or shutters, wired glass in standard metal frames, etc.*

INADEQUATE LIGHT

This should be guarded against by disposing the buildings so as to utilize the natural light to the best possible advantage.

Wherever practicable, buildings should be placed so that the windows of workrooms will not be obstructed by the walls of adjacent buildings. Where building structures of more than one story in height are necessarily placed close together, provision should be made in the building plan for open courts or light wells.† If the walls of such courts are white in color, a considerable amount of reflected light may be secured. One-story buildings can usually be satisfactorily illuminated by sky-lights, of which the familiar "saw-tooth" roof furnishes a good type.

SAFE ACCESS TO PLANT

Manufacturing plants are frequently located adjacent to railroads. Where they are on a main line, there may be considerable hazard to employees while entering or leaving the plant, from the necessary crossing of railway tracks.

This should be considered in locating plant entrances, and where the conditions are such that employees must cross railroad lines, a subway or viaduct should be provided to do away with any necessity for walking on the tracks proper. Where there are entrance facilities of this sort, it is desirable to have other means of egress shut off by walls or enclosures which will make it imperative for employees to use the safe entrances which have been provided. (See Page 15.)

Safe ways for passing from building to building within a given plant are also important. Doorways opening directly upon railroad tracks, and passageways where buildings or other obstructions obscure a view of the track, should be avoided so far as possible. Where this arrangement is found it should be corrected by blocking the passage, or by placing safety railings or gates with signs, gongs, watchmen, etc., which will call the attention of pedestrians to the danger from railroad equipment before they step out on the track. (See Page 19.)

SAFE YARD CONDITIONS

All walls, platforms, embankments, etc., 4′ or more in height, also edges of pits, excavations, ponds, streams, etc., 4′ or more in depth, near which employees work or may have occasion to pass, should be provided with standard railings or other effective barriers. (See Fig. 1, P. 15.) Temporary excavations should be marked with red lanterns at night.

Sewers, sumps, exhaust and blow-off pits, etc., should be equipped with substantial covers, preferably of metal. These should be arranged

* The Building Code recommended by the National Board of Fire Underwriters calls attention to the fact that heat from a burning building will break windows and imperil another building distant 60′ or more. It recommends fire doors or fire windows for all exposed exterior openings within 50′ of another building. For this and additional provisions of a similar nature, see Part XVI of the Code.

† See "Limits of Lot Area Occupied," Part IV of Building Code recommended by the National Board of Fire Underwriters.

Fig. 1. Doorway Protection. *

Fig. 2. Boy on Pole.†

Fig. 1 shows protection of doorways, consisting of removable railings in the upper door and swinging skeleton gates in the lower one. The latter are intended to prevent any one stepping out unexpectedly on the railroad track. These gates are so hung that they return to position by gravity after being opened.

Fig. 2 shows a boy climbing a pole which carries electric wires. The lower steps should be removed from such poles to a height of about ten feet from the ground, so as to discourage any such attempts. (See Fig. 2, P. 119.)

Metal pole steps near the ground are dangerous, since persons may strike them in passing, and be injured.

Figs. 3 and 4 show safeguards at corners of buildings which adjoin railroad tracks. The gong illustrated in Fig. 4 is arranged to ring constantly while any shifting is being done on this track.

Fig. 3. Guard-rail and Sign at R.R. Track.‡

Fig. 4. Warning Gong and Sign at R.R. Track.‡

* Courtesy of Tenn. C. I. & R.R. Co., subsidiary of the U. S. Steel Corporation.
† Courtesy of United Gas Improvement Co. ‡ Courtesy of American Steel and Wire Company.

so they cannot slip or give way while persons are passing over them. Permanent iron ladders should be installed in manholes or pits more than 4′ in depth.

Guy-wires, cables, rods, etc., if located where persons may come in accidental contact with them, should be enclosed in piping or boxes not less than 3″ in diameter, to a height of 6′. Such enclosures should be painted white so they will be more readily visible at night.

CHAPTER 6

FIRE RESISTANCE AND EXIT FACILITIES

THE hazard to human life from fire may be illustrated by the following table, which gives information on a number of serious fires occurring during the past few years: —

Fire	*Date*	*Building Construction*	*Height Stories*	*Lives Lost*	*No. and Type of Exits*
Asch Bld'g, N.Y. (Shirt-waist factory)	1911	"Fireproof"	10	145	2 Stairs, 1 Fire Escape
Binghampton Clothing Factory, N.Y.	1913	Brick, joisted	4	35	1 Stair,† 1 F.E.
High St. Factory, N.J.	1910	" "	4	24	1 Stair, 1 F.E.
Iroquois Theatre* Chicago	1903	"Fireproof"	(2Balc.)	586	2 Stairs, 2 F.E.
Opera House, Boyertown, Pa.	1908	Brick, joisted	3	200	1 Stair, 2 F.E.
Collinwood School, Cleveland	1908	Brick, joisted	3	173	1 Stair, 1 F. E.
Paris Bazar, France	1897	Light frame	1	124	8 (some not clearly designated)
Mo. Athletic Club, St. Louis	1904	Brick, joisted	7	30	1 Stair, 2 F.E.
Arcadia Lodging House, Boston	1913	Brick, joisted	5	28	1 Stair, 1 F.E.
Equitable Building, N.Y.	1912	"Fireproof"	8	6	1 Stair,† (and Elevators)

* Other serious theatre fires involving a large loss of human life are as follows: Lehmann Theatre, Petrograd, Russia, 1836 — 800 lives lost; Ring Theatre, Vienna, 1881 — 450 lives lost; Banquet Theatre, Oporto, Portugal, 1888 — 240 lives lost; Theatre, Exeter, England, 1887 — 200 lives lost; Municipal Theatre, Nice, 1881 — 150 lives lost; Opera Comique, Paris, 1887 — 115 lives lost; Royal Theatre, Quebec, 1846 — 100 lives lost; Richmond Theatre, Richmond, Virginia, 1811 — 70 lives lost.

† Only 1 *continuous* stair; some floors connected by stairways in addition to this.

In "Lessons from Fire and Panic" published by the British Fire Prevention Committee, Thomas Blashill mentions a church in Vezelay, France, which was burned in 1120, causing the death of 1,127 men and women; also a cathedral in a South American city, burned about 1830, in which 2,000 persons perished.

From these cases it is apparent that possibilities of serious disaster from fire may be present, under certain conditions, regardless of the height, construction, or use of a building. Two considerations of paramount importance immediately become apparent: —

1. The design of the building and the materials used in its construction should, so far as practicable, prevent the rapid spread of fire.
2. Sufficient exit facilities of a safe and dependable type should be provided, to enable all the occupants of a building to leave it quickly in case of fire.

The value of these considerations would seem to be self-evident; but the fact cannot be denied that a large percentage of the buildings which have been erected in the past, and many of those which are now being errected even by architects of good reputation, are decidedly lacking in one or both of these requirements.

The question of design and materials applies chiefly to new buildings, although much can be done in the way of safeguarding existing buildings. The question of exit facilities applies alike to both new and old buildings, although it may be difficult to secure facilities which are entirely satisfactory unless this matter is given the necessary attention while a building is being designed. Both of these questions have been given much study and thought during recent years by committees of the National Fire Protection Association and the National Board of Fire Underwriters.

The Committee on Safety to Life of the N. F. P. A., under the direction of the able fire protection and safety engineer, Mr. H. W. Forster, of the Independence Inspection Bureau, chairman of the committee, has prepared reports on exit facilities from which much of the material contained in the succeeding paragraphs has been taken.

Indebtedness is also acknowledged for the use of material from the report of the Committee on Fire Resisting Construction of the National Fire Protection Association, and from the Building Code Committee of the National Board of Fire Underwriters, of both of which committees Professor Ira H. Woolson, a recognized authority on building construction, is chairman.

DESIGN AND MATERIALS

The subject of fire-resisting design has been well covered in standard reference works such as the "Building Code recommended by the National Board of Fire Underwriters"; "Specifications for Construction of a Standard Building," mentioned above; "Handbook of Fire Protection for Improved Risks," Crosby-Fiske; "Fire Prevention and Fire Protection" and the "Fireproofing of Steel Buildings," Freitag. Reference should be made to such works for detailed information on the subject. The following discussion, however, gives certain important considerations which should be observed, in safe-guarding buildings against loss of life.

Fire Resistance.

The fact that it is impossible to construct a building which is literally "fireproof" should be clearly recognized. All building materials are affected more or less by continued exposure to heat, which may result from the burning of the building contents even though the materials in the building proper are incombustible. By way of illustration, the following examples may be cited: —

The walls of the Equitable Life Assurance Society's Building (New York) were of heavy brick and granite construction; the floors were of tile, concrete and brick, with wood surface on wood sleepers; structural members consisted of wrought-iron and steel girders, supported on cast iron and built-up steel columns; the roof was of brick surface and cinder fill on masonry arches, with steel framework. So much confidence was placed in this construction that no fire insurance was carried on the building; yet it was completely wrecked by fire. (See Page 23.) The columns and girders were inadequately fireproofed, and many of them buckled and deflected; others broke down entirely. That intense heat resulted from the burning of the wood trim, partitions, office furniture and equipment, was evident from the fact that glass and brass fixtures were melted, indicating a temperature of some sixteen hundred degrees. (See report of the New York Board of Fire Underwriters, excerpts from which were reprinted in "Insurance Engineering" for April, 1912.)

The Chamber of Commerce Building, Cincinnati, Ohio, was about 100′ by 150′ by 200′ high, had granite walls 6′6″ thick at base and 2′6″ thick at eaves, with steel skeletons. A fire started in the loft, presumably from a kitchen stove in the Men's Club. The unprotected steel roof trusses became heated, slowly yielded, and within fifteen minutes the top chord of the south truss buckled, dropping to the basement and pulling six other trusses from their seats. Published comments on this accident were to the effect that "the destruction of the building was almost unbelievable to those familiar with it, as it was generally considered a fair specimen of *fireproof construction*." (See "Engineering Journal," February 2, 1911.)

The recognition of these limitations of incombustible construction has resulted in the gradual elimination of the word "fireproof" as an engineering term. In its place is being substituted "fire-resisting" which more nearly describes the actual condition of the best form of building construction.

Types of Construction

From the standpoint of hazard to human life, buildings may be divided into three general types of construction, the desirability of which is in the order given below: —

1. Fire-resisting (or so-called "Fireproof") Construction.
2. Mill, or Slow-burning Construction.
3. Joisted, or Frame Construction.

Fire-resisting Construction

It is obvious that the best safety conditions are secured where a building is composed entirely of incombustible materials, such as steel, concrete, brick and tile. A slight amount of woodwork is commonly used in fire-resisting buildings, however, and if the quantity is not great, no appreciable increase in the hazard results.*

* The Building Code recommended by the National Board of Fire Underwriters, contains the following specifications in this connection: —

"No woodwork or other combustible material shall be used

Fig. 1. Equitable Building, N.Y.*

Fig. 2. Asch Building.*

Figs. 1 and 2 show the effect of fires in so-called "fireproof" buildings, both cases involving loss of life. The fireproofing in the Equitable Building was not properly arranged to protect the structural members (note buckled column in foreground). Both buildings had unprotected openings which resulted in the rapid spread of fire.

Fig. 3. Arcadia Lodging House. Fig. 4.

Fig. 5. Burned Stairway.

Figs. 3 and 4 show the Arcadia Lodging House (Boston) escapes, as arranged "before and after" the fire in which twenty-eight men lost their lives. Some jumped to their death, others were burned or suffocated. Flames poured up the one stairway in the building (Fig. 5), cutting off that means of escape almost immediately. The fire quickly blocked the exposed fire escape on the upper floors. The new escapes extend around three sides of the building, with swinging stairs leading to street. All windows are of swinging casement type instead of the former double-hung variety.

The smoke-marks above the windows in Fig. 3 indicate how easily the balconies around a fire wall may be cut off, unless protected from openings underneath.

* Courtesy of National Board of Fire Underwriters.

Care should be taken, however, that the value of good building construction is not lost, through the addition of such quantities of woodwork in the trim and furnishings, etc., as would maintain a considerable fire of itself. This has resulted disastrously in various fires, among which may be mentioned certain buildings in the Baltimore conflagration, the Granite Building of Rochester, and the Equitable Building of New York. (See "Disasters of Wood Trim and Combustible Furniture," by A. G. Patton, "Safety Engineering," October, 1913.)

The development of metal trim, furniture, shelving, filing cases, etc., makes it possible, without great hardship, to practically eliminate the use of woodwork, and this should be done in order to get the full benefit of superior fire-resisting construction in the building.

Mill Construction

The desire to reduce property loss by fire has developed the familiar type of Mill Construction building which is particularly adapted to factory use, and in which the maximum protection is afforded for the minimum cost.*

The principal feature of Mill Construction consists in the use of masonry walls and heavy timber interior construction, with no concealed spaces. Floors are of 2″ to 4″ plank, with top boarding, on heavy timbers spaced at least 6′ apart. Posts are of wood, not less than 8″ through (or of metal, thoroughly protected by fireproofing).

It has been demonstrated that this construction, when properly cut off between floors, offers much resistance to the spread of fire.† In a properly designed factory of moderate height, it should be possible for all occupants to escape within two or three minutes from the time a fire alarm is given. Where this is the case, it accordingly follows that Mill Construction is but slightly inferior to Fire-Resisting Construction, in minimizing the danger to employees after a fire has started.

Joisted or Frame Construction

Repeated experience has shown that buildings of this type might well be designated as "quick-burning" construction. It makes little difference whether the outside walls are of brick or wood, where the floors consist of thin boards on joists which expose the maximum ignitible surface for a given strength.

The hazard may be reduced by protecting openings between floors, sub-dividing large buildings by fire walls, installing automatic sprinklers, etc., as mentioned later; for buildings containing many employees or in which inflammable materials are to be handled, however, the use of Fire-resisting or Mill construction (preferably the former), is strongly recommended.

Heights and Areas

The Building Code recommended by the National Board of Fire Underwriters calls attention to the fact that five stories is the maximum height to which water can be effectively thrown by a fire department from the street level, and that fifty feet is the maximum distance inside a building which can be reached by a stream through the windows. The following limitations are accordingly recommended by the Code: —

in the construction of any fireproof building, except wooden floor sleepers, grounds, bucks, and nailing blocks when entirely embedded in incombustible material; also the finish flooring, and interior doors and windows, when not otherwise specified, with their frames, trim, and casings; also interior finish when backed solidly with fireproof material, may be of wood. Wooden wainscotings more than 3 feet high, or wooden ceilings, shall not be permitted.

"For the highest grade of fireproof building, incombustible surface flooring and metal trim should be used. Buildings of such construction are being erected in numerous cities, and are considered first-class investments."

* As a matter of fact, the difference in cost between Fire-Resisting Construction and Mill Construction is gradually disappearing, on account of the growing scarcity and consequent high price of good lumber. This will naturally result in a more general use of the former type of construction in the future, which, as it happens, is in the line of greater safety.

† In "Fire Prevention and Fire Protection," Chapter 4, Mr. Freitag refers to a Buffalo paper warehouse, six stories in height, burned in January, 1911. The building was of Mill Construction, and a photograph, taken thirty-six hours after the fire started, showed practically no damage to the structure in that time. The fire lasted for upwards of eighty hours, conditions necessitating its being fought entirely from the outside.

HEIGHT OF BUILDINGS

	Height in stories	*Height in feet*
"Fireproof" buildings used for purposes other than factories, stores, warehouses or workshops	10	125
"Fireproof" buildings used for factories, stores, warehouses or workshops	7	85
Non-fireproof buildings, mill construction	5	65
Non-fireproof buildings, ordinary construction (masonry walls, joisted floors)	4	55
Buildings having bearing walls of hollow terra cotta or concrete blocks	3	40
Frame buildings used for purposes other than dwellings	2	30

FLOOR AREAS

(*Maximum area of any floor between fire walls or exterior walls*)

1. "Fireproof" Construction Buildings—

Business buildings (factories, workshops, stores, warehouses, offices etc.) not exceeding 65 ft. in height.

Fronting on	*Without sprinklers*	*With sprinklers inc. 66⅔%*
One street	10,000 sq. ft.	16,666 sq. ft.
Two streets	12,000 " "	20,000 " "
Three or more streets	15,000 " "	25,000 " "

Factories, workshops, stores and warehouses, not exceeding 85 ft., and other buildings not exceeding 125 ft. in height.

Fronting on	*Without sprinklers*	*With sprinklers inc. 50%*
One street	7,500 sq. ft.	11,250 sq. ft.
Two streets	10,000 " "	15,000 " "
Three or more streets	12,500 " "	18,750 " "

2. Mill Construction Buildings (height limit 65 ft.)

Fronting on	*Without sprinklers*	*With sprinklers inc. 100%*
One street	6,500 sq. ft.	13,000 sq. ft.
Two streets	8,000 " "	16,000 " "
Three or more streets	10,000 " "	20,000 " "

3. Non-fireproof Construction (factories, workshops, stores, warehouses, offices, etc., height limit 55 ft.)

Fronting on	*Without sprinklers*	*With sprinklers inc. 66⅔%*
One street	5,000 sq. ft.	8,333 sq. ft.
Two streets	6,000 " "	10,000 " "
Three or more streets	7,500 " "	12,500 " "

Note: For further details, see Part VII of the Building Code.

The limitation of building height and floor area was developed primarily for the prevention of property loss by fire. Both of these limitations, however, are in the line of greater safety to human life, and may well receive the hearty support of those interested in this phase of the fire protection problem. The higher the building, other things being equal, the greater will be the fire hazard to its occupants; likewise, the larger the unrestricted floor area, the greater will be the difficulty in checking the spread of flames.

Each fire wall forms a stop which should serve as a limit to the fire. It also serves as a haven of refuge through which persons may pass in the minimum time and be comparatively safe. They can then leave the protected section without the haste that would be essential if they were still in the unprotected area.

In other words, the sub-division of a building by fire walls simplifies the provision of adequate exits, particularly where the installation of sufficient stairway capacity to empty the building within a safe time would otherwise be exceedingly expensive, if not impracticable. (See "Horizontal Exits.")

Provisions common to all Buildings

Other provisions of vital importance in reducing the hazard to human life, applicable to any building regardless of construction, are the following: —

1. Protection of vertical openings.
2. Protection of wall openings.
3. Protection by means of automatic sprinklers.

Protection of Vertical Openings

Unprotected vertical openings (elevator shafts, stairways, chutes, belt openings, etc.) furnish a ready means for the communication of smoke and flames from floor to floor. Such openings have figured largely in many disasters involving the destruction of human lives by fire. In that of the Binghampton Clothing Company, where thirty-five lives were lost, smoke drifting up the stairway apparently gave the first warning of impending trouble; flames quickly followed. In the Equitable Building, New York, the flames started in a small receiving room in the basement, poured upward through dumb-waiter shafts, and contributed fire to the upper floors so rapidly that several persons were trapped and lost their lives.

All openings from floor to floor should be thoroughly enclosed where either the building or its contents are combustible. It is very desirable to have stairways cut off by fire walls, for the protection of persons using them as well as to prevent spread of flames. This is also true of elevators.

Such enclosure should be provided in all fire-resisting buildings. Where cut-off or enclosed elevator shafts are considered impracticable for buildings of other than fireproof construction, draught-stops may be provided by the use of automatic fire hatches in the shaftway at each floor.

In the case of chutes, dumb-waiter shafts, etc., self-closing fire doors should be placed at every opening. Where it is necessary to fasten such doors open, temporarily, they should be provided with fusible links so they will close automatically in case of fire.

Belt openings can be completely enclosed in many cases. (See Fig. 4, P. 27, and Fig. 1-E, P. 161.) Where this is impracticable the opening should be reduced to the minimum possible size so as to eliminate any dangerous draught, (See Fig. 1-D, P. 161.)

For a further discussion of this subject, see Chapter 17 of the Building Code recommended by the National Board of Fire Underwriters.

Protection of Wall Openings

It is evident that the hazard to human life from fire, so far as it is affected by the building construction, has to do chiefly with fires which originate within the building. Under ordinary conditions the occupants of a building would have ample time to leave it, before fire contributed to it from an adjacent burning building could cut off their escape.

There is an element of danger in any conflagration, however, that is liable to result in loss of life, and from this standpoint, as well as that of avoiding property loss, it is desirable to prevent the spread of fire from building to building by protecting the wall openings on all exposed sides.*

Wired glass in standard metal frames, or standard fire shutters, may be used for such protection. Where the exposure is particularly severe a "water curtain," formed by open sprinklers along the eaves or cornice of a building (see Fig. 1, P. 29), may be employed. (See "Fire Protection Coverings for Window and Door Openings," National Fire Protection Association, Part XVI of the "Building Code Recommended by the National Board of Fire Underwriters," or the Crosby-Fiske Handbook, to which reference has already been made.)

Protection by Means of Automatic Sprinklers

Automatic sprinklers, from their effectiveness in extinguishing or holding in check a fire, form one of the most important safety precautions in any building where there is a material fire hazard. (See "Automatic Sprinklers," Chapter 40.)

EXIT FACILITIES

The great variation in the present legal requirements and architectural provisions for exit facilities in different parts of the country, show the need of some authoritative standards in this connection, which may be accepted as representing good practice.

The fact that the rapid and complete destruction of a building by fire is a comparatively infrequent occurrence, tends to obscure the necessity for making adequate provision for getting all occupants out of a building promptly. It is only when a great catastrophe occurs, attracting nation-wide attention, that the real situation stands out in relief. (See table on Page 21.)

Every such catastrophe is followed by a period of legislative activity and more or less radical improvement in the previous standards. There is no reason, however, why the matter should not be worked out in advance, and definite arrangements made which will eliminate the necessity for large sacrifice of human life in burning buildings. Such arrangements, with

* Such protection may also be of value in preventing the spread of fire from floor to floor in a given building. This method of progress has been observed in several fires, the most notable example probably being that of the Asch Building in New York, where the spread of flames from the eighth to the ninth and tenth floors was exceedingly rapid, and apparently almost entirely out and in the windows. (See report of the N.Y. Board of Fire Underwriters, April 4, 1911.)

Fig. 1. Arrangement for Closing Fire Shutters.*

Fig. 2. Naumkeag Storehouse after Salem Fire.

Fig. 1 shows a device for simultaneously closing all fire shutters on the side of a building.

Fig. 2 illustrates the effectiveness of approved fire-resisting construction. Wall openings were protected by fire doors and wired glass windows. This building effectively withstood the conflagration which swept around all four sides of it.

Fig. 3. Shipping Room, Edison Phonograph Works, after Fire.†

Fig. 4. Fire-Resisting Belt Enclosure.‡

Fig. 3 shows the effect of intense heat on columns of re-inforced concrete building. In some cases the concrete was actually melted. Lack of proper window protection was an important factor in the spread of this fire, which destroyed some ten or twelve buildings. The 5500 employees marched out when the fire-drill signal was sounded, and only one employee, who returned for personal property, was killed.

In Fig. 4, the use of fire-resisting enclosure for belts passing through floors is shown. This serves as a fire stop, and also prevents accidental contact with the belt. The cement is 2″ thick, on metal lath and framework of 1″ channels.

* Courtesy of Boston Elevated Railway Company. † Courtesy of National Board of Fire Underwriters.
‡ Courtesy of Associated Factory Mutual Fire Insurance Companies.

definite standards wherever practicable are outlined in the following discussion.

Minimum Number of Exits

All buildings more than one story in height should have at least two exits from each story, placed at opposite ends of the building or otherwise separated in such a manner that they cannot both be cut off by a fire of limited extent. Where a floor is divided into separate rooms of any considerable area there should be at least two doors or other suitable means of egress from each of these rooms.

This should be considered a minimum requirement, so that in case a sudden fire, explosion, or other unexpected occurrence should prevent the use of one stairway or exit, a second will be available.

Types of Exits

The Committee on Safety to Life of the National Fire Protection Association, to which reference has already been made, has listed the various means of egress in general use, their desirability being approximately in the order given below: —

Horizontal Exits	Openings in Fire Walls or Fire-resistive Partitions (see Page 37). Bridges to Adjacent Buildings (see Page 37.) Balconies around Fire Walls (see Fig. 2, P. 29).
Smoke-proof Towers	with Interior Vestibule (see Page 37). with Exterior Balcony (see Page 31).
Cut-off Stair Shafts	(see Page 37).
Interior Stairs	Completely Enclosed. Semi-enclosed (see Fig. 4, P. 70). Open.
Outside Stairs ("Fire Escapes")	Superimposed (see Figs. 1 and 2, P. 35). Straight Run (see Fig. 3, P. 31).
Elevators	Cut-off (by Fire wall). Enclosed Shaft (see Figs. 2 and 3, P. 191). Open Shaft (see Fig. 5, P. 189).
Chutes	Straight (see Fig. 1, P. 33). Spiral

Outside Ladders

Individual Fire Escapes (see Fig. 3, P. 33).

Poles (for sliding, see Fig. 1, P. 33).

Horizontal Exits

Obviously one of the most rapid methods of moving people out of a given area is by means of horizontal exits, such as openings in fire walls or fire-resisting partitions, or by means of balconies around fire walls or bridges to adjacent buildings.

For openings in fire walls the Committee on Fire-Resistive Construction of the N. F. P. A. gives the following specifications: —

a. An opening serving as an emergency exit, not to exceed 48 square feet in area.

b. A self-closing door to be substituted for one of the automatic doors generally specified for both sides of fire wall openings.

c. Either of the two connecting areas to contain the occupants of both sections on a basis of not less than 5 square feet of floor space per person.

d. Each area to have at least one stair exit, of the smoke-proof tower or enclosed staircase type, and no point of any floor area to be more than 100 feet distant from an exit.

The report of the Committee on Safety to Life of the N. F. P. A. calls attention to the fact that the mere provision of an opening in a fire wall does not mean complete safety. There must be adequate facilities for moving persons downward as soon as they have passed through the wall. When a fire starts, the natural result is an attempt on the part of the occupants to extinguish it. The fire fighters may continue their efforts until, in their final rush for safety, they have no opportunity to shut the door.

In a building with a division wall, a single fire door, not closed, or failing to close automatically, may admit fire to the protected section or to the stair tower and jeopardize life almost as seriously as if no horizontal exit existed.*

It should also be borne in mind that the employees cannot be depended upon to remain

* This is just what happened at a fire in Newark, N.J., on March 14th, 1914. The fire passed through a partially open fire door and ran up the stair shaft, cutting off the exit through the fire wall. Nearly four hundred girls on the upper floors marched down the outside stairway to safety. (See Fig. 2, Page 338.)

Fig. 1. Water Curtain. (United Shoe Machinery Company.)

Fig. 2. Balcony around Fire Wall.

Fig. 1 shows water curtain protection for the exposed side of a building.

Fig. 2 shows balcony type of escape from one building to another. Windows underneath such escapes should be protected with wired glass or fire shutters.

Fig. 3. Asch Building Fire.*

Fig. 4. Victims of Asch Building Fire.*

Fig. 5. Roof Escape.*

Fig. 3 shows progress of fire in eighth, ninth, and tenth floors of the Asch Building. At such heights hose streams are of little value; automatic sprinklers are the most effective means for coping with such a fire.

Fig. 4 shows officers attempting to identify employees, about 40 of whom jumped to the street and were killed. A number of persons escaped from the Asch Building to an adjacent building by means of ladders illustrated in Fig. 5, thus showing the value of roof escapes.

* Courtesy of General Fire Extinguisher Company.

cool and collected in case of an actual fire. They may forget the element of safety that is afforded by the fire wall and become panic stricken. It is accordingly important to have an orderly method of emptying the building, such as is afforded by a fire drill. (See Chapter 42.)

It is essential to provide adequate exit facilities for removing, within a reasonable time, all occupants of a given area, as well as those of an adjacent area dependent on it for protection. The provision of a fire wall may well lengthen the time which would otherwise be required to empty the building. It is accordingly recommended that an area protected by a fire wall must have at least one-fourth the stairway capacity which would be required for its own occupants combined with those of any single adjoining area that may "exit" through it. (See "Exit Capacity Schedule.")

Bridges around fire walls, being on the outside of the building, necessitate the occupants passing through the open air, and for this reason afford a certain element of reassurance.

Bridges to adjacent buildings are even more effective in allaying a feeling of panic, since they remove the occupants entirely from the burning building.

Protection of bridges. Unless they are located on dead walls there is danger of unprotected outside bridges being rendered impassable by smoke and flames from the floors below.

One method of providing the necessary protection in such cases is to construct the bridges with floors solid (except for small drainage openings) and with solid enclosing walls (of sheet steel, metal lath and plaster, etc.) to a height of seven feet.

A second method is to protect windows which might endanger such bridges. The standard recommended (tentatively) by the Committee on Safety to Life of the N. F. P. A. in this connection is as follows: —

Protected wall zone to be determined by projecting lines 60° from the vertical, outward and downward from points 6′ to each side of the bridge. Wall openings, one-half or more of whose area falls inside of this zone, shall be protected with approved stationary wired glass windows or approved fire doors, but this protection need not extend more than two stories below a balcony around a fire wall or one story below a bridge to an adjacent building. (See Fig. 2, P. 37.)

Smoke-Proof Towers

The smoke-proof tower is a stairway cut off entirely from the building by fire-resisting walls through which there are no openings. Persons using the stairway are thus thoroughly protected from smoke or flames, even though the building may be burning immediately adjacent to the stairway.

Access to the tower is provided by means of interior vestibules open to the outside air, or exterior balconies. (See Page 31, and Page 37.) Door openings leading to these vestibules or balconies are provided with fire doors swinging in the direction of travel to the stairway.

Cut-Off Stair Shafts

This refers to the type of stairway commonly used in Mill Construction buildings, enclosed with fire-resisting walls and cut off at each floor with fire doors. Such stairways are somewhat inferior to the "smoke-proof tower," in that there is direct communication with the building, and failure of or blocking of a fire door, might permit smoke and flames to enter the stair shaft.

Swinging doors may be used for cut-off stair shafts, where the doors are kept closed normally. This frequently is possible in high buildings where there is little use of the stairs. Swinging doors are not easily made automatic, however, and may interfere with travel down the stairs unless landings are wide. The Committee on Safety to Life accordingly feels that sliding, gravity-closing, automatic doors are acceptable in many locations.

A good arrangement for doors in stair towers or shafts is to have an automatic sliding fire door on the factory side of the wall, with a self-closing* swinging door (not necessarily a fire

* *A self-closing* door is one with a spring or other mechanical device for closing it. *An automatic* fire door is one arranged to close automatically when released by a fusible link, through the action of heat.

Fig. 1. Balconies leading to Smoke-Proof Tower.*

Fig. 2. Two Types of Approved Emergency Exits on one Building.*

An artistic and effective arrangement of balconies for smoke-proof towers is shown in Fig. 1.

Fig. 2 illustrates balconies leading to smoke-proof tower (on the left), and an outside stairway. Note high enclosure of the latter, which prevents danger of persons falling over the railings.

Fig. 3. Protected outside Stairways "Straight-Run" Type.*

Fig. 4. Smoke-Proof Tower with Balcony Entrances.*

Fig. 3 shows a good arrangement of outside stairs on a theatre. The wall is blank, except for the door openings. Note bracket method of support, and protective hood.

Fig. 4 shows balconies with solid floors, — an excellent form of construction. Windows adjacent to balconies are protected by wired glass.

* Courtesy of National Board of Fire Underwriters.

door) on the stair side. The swinging door is kept normally closed and will retard to a large degree the passage of smoke and flames. In case the swinging door should be left open, or the fire should threaten its stability, the automatic sliding door would close and give complete protection.

Interior Stairs

In order to be effective as means of escape in case of fire, interior stairs should be completely enclosed. While such enclosure should preferably be of fire-resisting construction, there is considerable value in even a light wooden enclosure in keeping smoke out of the stairway, and in preventing draughts which may quickly transform an open stair shaft into a flaming flue.

The semi-enclosed stairway, in which persons descending must pass outside the enclosure and enter each story on their downward travel, is decidedly objectionable.

Open stairways should not be permitted where there is any material fire hazard, both because they assist in the rapid spread of flames and because they cannot be depended upon as means of egress.

A fairly common practice, which can only be condemned, is that of placing stairways around unenclosed elevator shafts, thus putting "all the eggs in one basket," so to speak. If smoke or flames penetrate to either the stair shaft or elevator shaft, both are cut off together at the very time they are most needed.

All exit doors in rooms or buildings where there are a considerable number of persons, say 15 or more,* should open outward. Where it is desirable to keep a door locked to prevent the intrusion of unauthorized persons, an automatic or self-releasing latch may be used. This consists of a horizontal bar across the door arranged so that a slight pressure against it from the inside will release the latch and permit the door to swing outward. (See Fig. 4, Page 33.)

* This is the standard recommended in the Building Code of the National Board of Fire Underwriters, and would seem to be reasonably severe, although the New York law specifies the number of persons as 5.

It is poor practice to lock an exit door so that it cannot be opened readily from the inside. The statutes of some States specifically for bid this practice. If, under special conditions, it is considered essential to lock a door in this manner, the key should be placed in a box with a break-glass front, immediately adjacent to the door; or, better still, the key may be left in the lock and the box built around it. A chained hammer or other suitable means for breaking the glass should be provided. (See Fig. 3, Page 131.)

Where doors open upon passageways, the latter should be of such width and arrangement that an open door will not blockade the passageway.

Unless stairway flights are continuous, that is, with the foot of one flight immediately adjacent to the head of the next lower one, conspicuous signs should be provided, to guide those using the stairway in the proper direction.

The Building Code of the National Board of Fire Underwriters calls attention to the desirability of interrupting the line of travel at the street or ground level, where necessary to prevent danger of persons using the exit continuing down the stairway and into a basement or subbasement.

Stairway Terminals

After all other requisites have had adequate attention, emergency stairways or exits may fail of their purpose and become mere traps, unless proper consideration be given to the terminal arrangements.

Stairways should terminate at the foot in such a way that persons using them will have free access to a place of safety, from the end of the last flight. Dead-ends should be avoided, as well as obstructions or enclosures of any sort which might congest or check progress.

The necessity for such arrangements seems so obvious that one would think they could not be overlooked, yet this is often done. In the Iroquois Theatre fire, a stairway from the upper gallery, instead of leading to the street as might naturally be expected, terminated in a private office with a locked door. It is said that

Fig. 1. Chute and Pole Types of Escapes.*

Fig. 2. Apartment House after Fatal Fire.

Vertical sliding poles or straight chutes, as illustrated in Fig. 1, are effective where hasty exit is imperative.

Fig. 3. Individual Escape.

Fig. 4. Type of Self-Releasing Latch for Exit Doors.

Fig. 2 shows a building just after a fire in which eight lives were lost. There were five means of exit, including stairways and fire escapes; these were poorly arranged, however, and several persons were unable to reach them. The unprotected fire escapes were quickly cut off by flames.

Fig. 3 shows a man (at A) using an "individual fire escape." This consists of a steel cable with a safety belt at either end. As a person in one belt descends, another belt (B) is raised ready for use. The speed of lowering is controlled by an automatic regulating device.

A good type of emergency latch for exit doors is shown in Fig. 4. It permits the door being locked to prevent the entrance of unauthorized persons, but releases and opens the door if the horizontal bar is pressed. This prevents danger of persons jamming against exit doors which cannot be opened quickly, in case of panic.

* Courtesy of E. I. du Pont de Nemours Powder Company.

no less than thirty bodies were found in the trap thus formed. (Freitag.)

In the Asch Building, the fire escape led to an enclosed court, so that those who succeeded in reaching the ground had difficulty in getting out of the court.

When the well-remembered disaster at the Paris Bazaar occurred, many people were burned to death in an open yard at the rear, from which there was no outlet.

Where stairways with dead ends necessarily exist, they should be marked with a conspicuous sign such as "NOT THE WAY OUT."

It is important that all stairways lead to the roof. This may permit of escape after all other ways are cut off. In the Asch Building fire a number of people on the tenth floor made their way out over the roof. (See Fig. 5, P. 29.)

The Cripplegate fire (England) originated in a manufacturing warehouse, the two upper stories of which were occupied by some seventy or eighty workgirls. This happened to be one of the first buildings dealt with by the London City Council under the new Factory Act of 1891, and at its direction, the owner of the building had provided a door leading to the roof. Through this door all were able to escape; without it, they must have perished. (See "Lessons from Fire and Panic," publication number nine of the British Fire Prevention Committee.)

It is worthy of further mention, that even with this relatively easy method of flight, considerable difficulty was experienced in getting the girls out in the few minutes available, some of them having fainted or having become uncontrollable from their excitement. This is a contingency which is liable to arise at any fire, and which should be kept in mind when planning emergency escapes from a building, particularly where any of the occupants are women.

Outside Stairs

The wording "Outside Stairs" has been employed in the recent Building Code of the National Board of Fire Underwriters, to differentiate a well designed and installed set of outside stairs from the generally ineffective fire escapes in common use.

The outside fire escape, as constructed in the past, has fallen into well-deserved disrepute. Such escapes are generally unprotected against fire from window openings underneath. They are very frequently of poor design, particularly from the standpoint of steepness, narrowness and railings of inadequate height. Suitable ladders or stairs from the second floor to the ground are sometimes lacking entirely, or a complicated and inefficient arrangement of vertical drop ladders is provided. The common open-work construction, permitting a practically unobstructed view to the ground below is likely to cause dizziness or hesitancy on the part of those attempting to use the escape, particularly where women or children are concerned. The escapes are often inaccessible to many portions of the building except by going through halls which may be impassable from smoke and flames. On account of being infrequently used they are liable to be obstructed or in poor condition when needed.

In many cases the so-called fire escape has proven to be a mere trap. The Binghampton and Asch Building fires may be cited as examples. (See Figs. 3, 4, and 5, on opposite Page.) In both cases persons attempting to use the fire escape were given the alternative of being grilled alive or jumping to their death in the streets below.

On the other hand, there is no reason why a properly designed escape of this kind cannot be made reasonably safe and effective as a means of emergency egress. The Committee on Safety to Life of the N. F. P. A., feeling that the above mentioned distinction between "Fire Escapes" and "Outside Stairs" is an excellent one, has adopted the latter wording and prepared tentative specifications for Outside Stairs, which were presented in practically the following form by the Chairman, Mr. Forster, at the 1915 annual meeting of the Association (see "Proceedings" for 1915.) These specifications have not been finally approved by the Association at the time this matter goes to press, and are accordingly subject to modification.

Fig. 1. Outside Stairs Parallel (on left), and at Right Angles (on right), to the Building.*

Fig. 2. Outside Stairway protected by Wing-Wall.*

Wall openings adjoining and underneath fire escapes shown in Figs. 1 and 2 are protected by fire doors, wired glass windows and a wing-wall (Fig. 2) 3′ wide, of solid sheet steel.

Fig. 3. Fire Escape on Asch . Building.*

Fig. 4. Smoke drifting from Windows During Fire.†

Fig. 5. Fire Escape, obscured by Smoke.‡

Figs. 3, 4, and 5 illustrate the ineffectiveness of the ordinary outside "fire escapes." Fig. 5 shows the Binghampton Clothing Factory a few minutes after the fire started; hose stream points towards fire escape.

* Courtesy of National Board of Fire Underwriters. † Courtesy of General Fire Extinguisher Company.
‡ Courtesy of "Safety Engineering."

Specifications for Outside Stairs

Height of Building

Except they be enclosed in a tower, outside stairs, even if well designed and erected, are not recommended on buildings over six stories in height. The fundamental reason lies in the timidity of persons at a considerable height, no matter how safe the conditions may actually be.

Types

These specifications cover outside forms of stairs, either attached to buildings or erected independently of them, but connected by bridges.

Types in common use are: —

(*a*) Stairs in superimposed form (parallel to or at right angles to buildings).

(*b*) Straight run stairs (parallel to or at right angles to buildings).

Superimposed stairs, if enclosed, generally form a smoke-proof tower. (Spiral stairs are not recommended).

Straight run stairs are not feasible where exits must be approximately in a vertical line. The protection of window openings is also likely to be more costly with this type of stairway than with the superimposed form.

Where ramps are used as exits for hospitals, or leading to floors of near-by buildings not at same level, a slope of not more than 2½-inch rise in 12 inches of length is advised.

Ladders are deemed inadvisable in all cases except for use of fire department from top floor to roof.

The following detailed specifications shall apply in so far as possible to all of the above types of escapes or to any other forms which may be erected: —

Location

The following paragraphs indicate the order of desirability:

Stairs enclosed in towers with access through outside balconies or vestibules.

Stairs entirely shielded by blank walls, access from wall openings to stairs being by horizontal balconies.

Stairs shielded by approved **stationary** metal frame windows glazed with wired glass, and balconies extending in one or both directions to openings protected with approved fire doors or wired glass windows.

Where windows cannot be stationary on account of ventilation requirements or for other reasons, stairs shielded by approved wired glass windows and (or) approved fire doors, designed to afford ready egress and yet reduce to a minimum the danger of flames reaching the stairs and balconies.

Methods of stair protection in use include: —

(*a*) Doors used for ventilation and egress.

(*b*) Casement windows similarly employed.

(*c*) Double hung windows similarly employed.

(*d*) Pivoted windows (not used for escape).

Protected zone for stairs of types previously described shall be as follows: —

(*a*) For superimposed stairs: zone determined by drawing lines 60° with the vertical outward and downward from points 6 feet to each side of projected stair length at highest level reached by stairs. All openings one half or more of whose area falls inside of this zone shall be protected. Protection need not extend around a right angle corner of wall where stairs are close to such corner. (See Page 37.)

(*b*) For straight run stairs: protection shall be as above on side away from direction of stair slope and below entire stairway to ground, and in addition all wall openings, any part of which is within 7 feet of stairs or platforms as measured vertically, shall be protected for their entire area.

(*c*) For vertical ladders leading from top story to roof, protection shall begin at least 6 feet from each side of ladder, and where 60° line passes balcony of top story, the protection shall be at least 6 feet on each side of projected stair length.

(*d*) In lieu of the above described protection, superimposed stairs and ladders leading to roofs may be protected from openings not directly underneath them, by fire-resisting wing walls, projecting at least 2 feet beyond outside line of balcony and stairs.*

Wall opening protection is not essential in the top story, reached by outside stairs, except when stairs or ladders are carried to the roof.

Access

Insufficient attention has been given the fact that means of escape on office buildings, hotels, clubs, dormitories, apartments and similar structures, are often difficult to reach, especially if halls are filled with fire or smoke. On an open factory floor, all persons can usually reach the exits to outside stairs, but in laying out any system of escape, due recognition should be

* (Author's note.) The desirability of this form of protection is questionable, and its use will probably not be advocated (with the possible exception of special locations where it is peculiarly applicable).

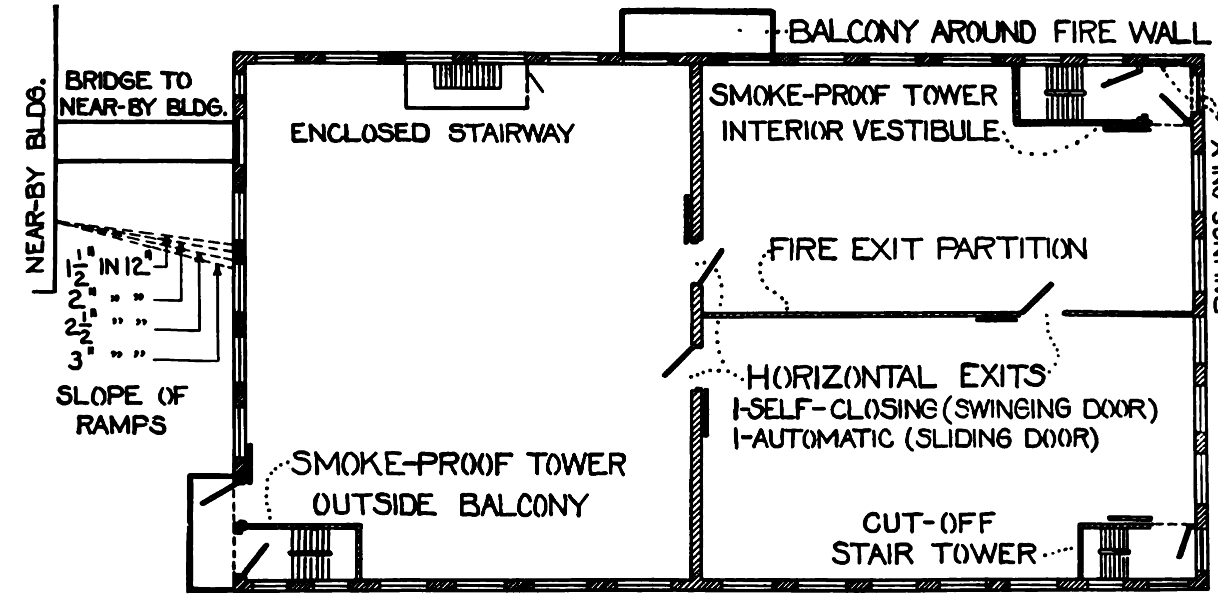


Fig. 1. Types of Horizontal Exits, Stairways, etc.

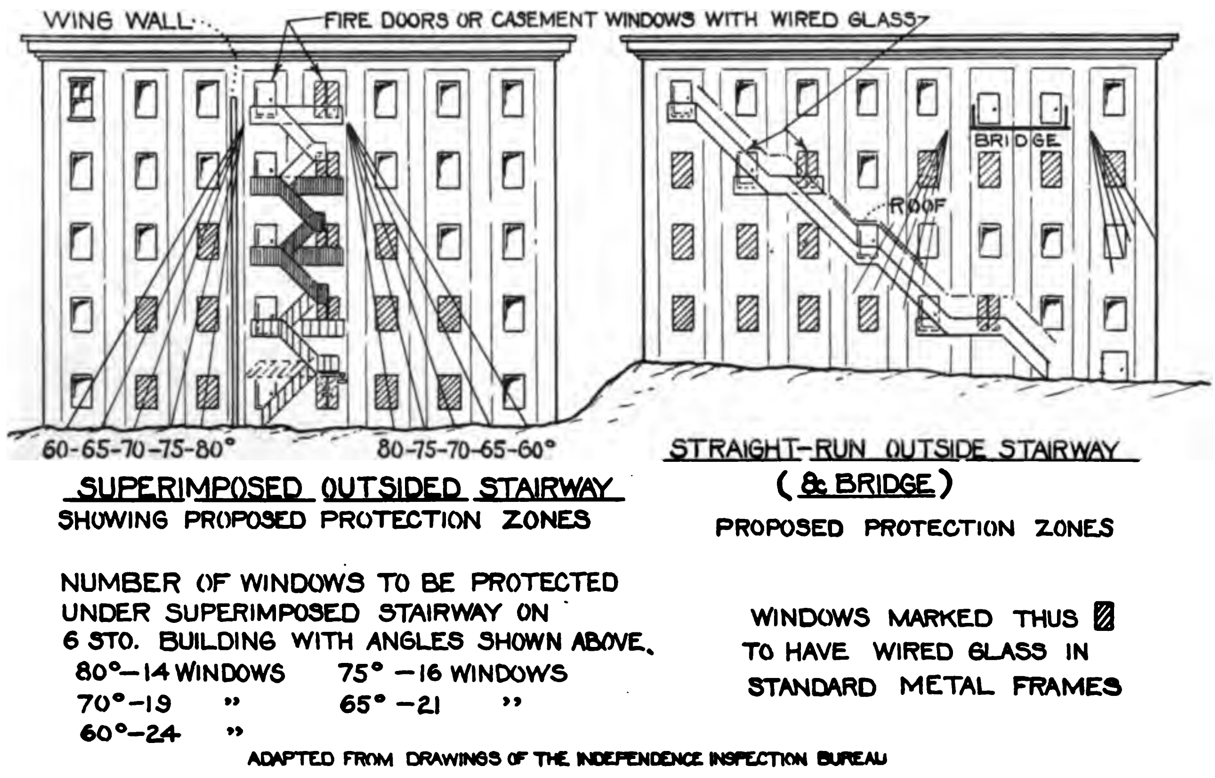


Fig. 2. Drawing illustrating Proposed Methods of protecting outside Stairways from Wall Openings underneath.

The necessity for such protection has been shown in many fires, and the National Fire Protection Association is now working on its standardization. Fig. 2 illustrates protection zones, with a maximum width of 60°, which have been proposed tentatively.

given this important principle. Only the best arrangements should be permitted on new buildings.

Stairs shall reach all floors above the first, shall be continuous to the ground, or terminate in a swinging stair section, and shall continue to the roof if this is a means of exit to adjoining or near-by buildings, or a safe place for persons to remain. If for fire department use only, a vertical ladder to roof is deemed sufficient.

Unobstructed aisles, at least 6 inches wider than opening or openings to outside stairs shall be provided. Space in front of windows or doors to such openings shall be kept clear. No grating, bars nor other obstructions shall be placed at or over any such openings, provided that hinged or easily removed screens may be used, and that it is recognized to be impossible to give persons confined in some institutions unlocked access to means of egress from the building.

Doors and casement windows are preferred to double hung windows for giving access to outside stairs. Double hung windows, if used, shall operate readily and be counterbalanced.

Doors and casement windows shall swing so as not to interfere with travel.

Doors and casement windows to outside stairs shall have minimum width of 30 inches and minimum height of 78 inches.

Double hung windows, if used for access to outside stairs, shall have minimum width of 30 inches and minimum clear height of 36 inches. Doors and casement windows shall preferably have openings approximately flush with floor of building, sill to be not over 2 inches high. If door sill is over 12 inches from floor of building, steps shall be provided, and shall have risers approximately $7\frac{3}{4}$ inches high, and treads not less than 9 inches wide, exclusive of nosings.

Outside balconies shall preferably be flush with wall openings, shall not be more than $7\frac{3}{4}$ inches below wall openings, and never above them.

Material and Strength

Iron, steel, and concrete only, shall be used, no wood to be employed.

Balconies and stairs shall be designed to carry a load of 100 pounds per square foot, with a factor of safety of 6.

NOTE. — This factor of safety is larger than ordinary practice, and is recommended because outside stairs and balconies are unusually subject to weakening through corrosion.

Stairs shall be designed to support a concentrated load of 200 pounds at the center with a factor of safety of 6.

All supporting members for balconies and stairs which are in tension shall pass through the wall, and be secured on opposite side with wall plates and lock nuts, or they shall be securely fastened to steel framework of the building.

Balcony and stair enclosures and railings shall be designed to withstand a horizontal pressure of 200 pounds per running foot of railings or enclosure without serious deflection, and support at walls for such railings or enclosures shall be in manner specified above for tension members.

Balconies

Size. Where stairs are in superimposed form the length of the balcony shall equal the horizontal length of the stair runs plus an amount at each end at least equal to the width of the stairs. On straight run stairs, the balcony shall be at least 4 feet long. The width of balcony, where stairs are in superimposed form, shall be at least 50 inches between inside of railings, and in straight run stairs shall be at least 3 feet inside of railings.

The minimum clear unobstructed width of any outside stair passageway, whether parallel to building, or at right angles to it, shall be 24 inches.

Floors shall be solid, arranged to prevent slipping, and pitched to secure drainage.

NOTE. — Reinforced concrete, checkered steel plates and safety floorings are among materials available for solid floor construction. Solid floors are specified chiefly to shield against flame, and to prevent timidity on the part of persons using stairs. Slatted floor construction may be permitted within, say 30 feet of the ground.

Enclosures shall be not less than 42 inches high, shall preferably be solid; if of slatted or grilled construction, no space shall have a horizontal width of more than 3 inches.

Enclosures throughout their length shall be free from obstructions tending to break handhold.

Enclosures or railings shall be provided for floor openings for stairs, except at head of stairs, and such enclosures or railings shall be capable of resisting the same horizontal pressure specified for outside ones.

Passage space shall be smooth and free from any projections or other obstructions.

Floor openings for stairs shall be not less than 24 inches wide, and of sufficient length to provide for at least $7\frac{1}{2}$ feet head room, as measured vertically from the stair perpendicularly below the edge of opening.

Landings at head and foot of stairs shall be at least as deep as width of stairs.

Stairs

NOTE. — For theatres and other places of public assembly, and for schools, hospitals and similar buildings, wider stairs and balconies than specified herein will frequently be necessary. Attention is called to the 1913 specifications of the N. F. P. A. Committee on Theatres, and to the National Board of Fire Underwriters' Building Code.

The pitch of stationary and swinging stairs (when down) shall not exceed 45°.

Rise shall not exceed 9 inches. Seven and three-fourths inches is recommended.

Treads shall not be less than 9 inches, exclusive of nosings.

Treads shall be solid, and there shall be no winders.

Risers shall preferably be provided on stationary stairs, and, if provided, shall be not less than 3 inches high as measured from the tread.

Risers shall be provided for swinging stairs, and shall be full height of stairs, except that space not less than ½ inch and not more than 1 inch shall be left immediately above treads to provide drainage.

Where risers are installed, nosing not less than 1 inch wide shall be provided.

The maximum vertical distance between platforms or landings shall not exceed 12 feet. Designs involving many landings and short flights of stairs are not recommended.

Minimum width of stairs between rails shall not be less than 24 inches.

Railings shall be provided on both sides of stairs, and have height not less than 42 inches as measured vertically from center of stair treads. Space between rails and stringers shall preferably be filled in solidly, or with slat or grill constructions, or triple railing may be used.

For schools which small children attend, it is advisable to provide a hand rail about 30 inches above the center of the tread in addition to higher one required to safeguard adults.

Where possible, stairways shall be built permanently to the ground, and this shall be required in such buildings as schools and hospitals where escapes do not terminate over streets, alleys or private driveways. At all other points, escapes shall terminate in swinging stairway, to which the following specifications shall apply: —

(*a*) Width of stairs and character of railing protection to be same as specified above.

(*b*) If distance from lowest platform to ground exceeds 12 feet, an intermediate balcony not more than 12 feet from ground shall be provided, and shall have size not less than width of stairs and not less than 4 feet in length.

(*c*) Counterweight shall be provided for swinging stairs, and this shall be of type balancing about a pivot, no cables being used. Counterweight shall be securely bolted in place, except sliding ball weights or their equivalent be used to hold stairs up and to help lower them. Counterbalancing shall be such that a weight of 150 pounds, one step from pivot will not start swinging section downward, and a weight of 150 pounds one quarter of the length of the swinging stairs from the pivot will positively cause stairs to swing down.

(*d*) Pivot for swinging stairs shall either have a bronze bushing or have sufficient clearance to prevent sticking on account of corrosion.

(*e*) No latch to lock swinging stair section in up position shall be installed.

(*f*) Latch is suggested to hold stairs in downward position when they have once been swung to ground.

(*g*) Railings shall be designed to prevent any possibility of injury to persons on stairs or balconies at its head when stairs swing downward. Minimum clearance between moving sections where hands may be caught shall be 4 inches.

The minimum clearance at all points on balconies and stairs as measured vertically shall be 7½ feet.

Ladders

(Author's note.) The specifications for stationary ladders carried from top balcony to roof are practically identical with the standards for iron ladders given in Chapter 24.

Protection over Stairs

Roof or canopy over stairs, especially if of the straight run type, has value as protection against rain, snow, accumulation of ice and falling of icicles. (See Fig. 3, P. 31.)

Lights and Signs

Green indicating lights (where red is not required by law) shall be provided at all exits to outside stairs in buildings which are used during the night, and lights shall be kept burning during the night-time if building is occupied. Two independent sources of light shall preferably be provided.*

* (Author's note.) The lack of this provision may result in a panic and serious loss of life, through the failure of the ordi-

Signs having white letters not less than 5 inches* high on a green field, indicating location of outside stairs, shall be provided not only on or near windows or doors leading to stairs, but also at other points in building wherever deemed necessary.

If access to outside stairs is through any room, doors shall preferably be arranged so that they cannot be locked. If not so arranged they shall have thin glass panel, and sign on this reading, "To outside stairs, break glass and open door," or some equivalent wording.

Any such indirect method of reaching outside stairs shall be allowed only on existing buildings.

Care

After being erected, outside stairs shall be painted.

Outside stairs shall be scraped and painted at least once a year thereafter.

Outside stairs shall be kept clear of incumbrances.

Outside stairs shall be promptly cleaned after snow or ice has accumulated upon them.

No obstructions such as lighting or telephone wires shall be permitted on or near outside stairs.

Particular attention should be paid to possible interference by awnings at windows or over sidewalk, and to other obstructions at or near the street level.

Elevators

Little dependence can be placed on elevators as a means of emergency egress. It is obvious that where several floors are served, in the case of a serious fire all would be demanding the elevator at the same time, thus confusing the operator where one is provided. Where there is no regular operator, this conflicting demand would, in all probability, entirely prevent the effective use of the elevator. The intermittent nature of elevator service is likely to result in much disturbance and overcrowding between trips.

The elevator equipment may be out of commission at the time a fire occurs, or an explosion or other untoward occurrence which starts a fire or panic may also render the elevators inoperative. Unenclosed elevator shafts are almost certain to be cut off in case of fire. Even where elevator shafts are enclosed, a single door left open may admit fire and smoke and render the shaft impassable.

For these reasons, elevators should not be considered as supplying part of the needed egress capacity in ordinary factory buildings. The New Jersey regulations prohibit the use of elevators for such service.

In high structures, such as the modern office building, of say ten stories or more in height, it is absolutely necessary to place more or less dependence on elevators for emergency egress. Such buildings, however, contain a large potentiality of disaster and the elevator shafts should be protected from fire in the most approved manner. Doors leading to the shafts should always be kept closed except when in actual use.

Particular attention should be paid to insuring the integrity of the electric current or other power supply for the elevators against any small fire in the neighborhood which might cripple the elevator service.

It is also important to drill elevator operators as to the proper method of procedure in case of fire, the fundamental principle unquestionably being that persons in the upper stories of the building shall first be taken to the ground, and that no persons below the fire shall be carried on the elevators so long as any above it remain in the building.

Chutes

Persons may escape quickly from buildings by means of chutes, where there are convenient terminal facilities and where the chutes are kept smooth and in good condition. For such service straight chutes are preferable to spiral ones. The condition of a straight chute can be more readily observed, and it can be ascertained from the top whether the way is clear or not. (See Fig. 1, P. 33.) Spiral chutes are usually dark, and corrosion or any other difficulty which will prevent free passage may cause an obstruction, and introduce an element of

nary source of light and the occupants of the building struggling in the darkness in an effort to get out. Where electric light is used, the emergency supply may be obtained from a storage battery or from some outside source of current. This may be arranged with an automatic switch which will immediately throw on the reserve system whenever the regular current fails. (See Fig. 4, Page 131.)

* (Author's note.) This is the standard in Massachusetts; the New York law specifies a minimum height of 8".

genuine hazard. This device cannot accordingly be very strongly recommended.

In any cases where chutes are provided, it is important that the building occupants be drilled in their use, and that the chutes be kept in good condition at all times.

Outside Ladders

Vertical ladders are of little value as a means of emergency escape and should never be used where women are employed, where many persons are dependent on them, or where the provision of better facilities is practicable. (For ladders to roof, intended particularly for the use of firemen, see "Outside Stairs.")

Where ladders are installed they should be of standard construction, and equipped with safety cages where the height warrants this provision. (See Chapter 24.)

Individual Fire Escapes

The report of the Committee on Safety to Life of the N. F. P. A. contains the following comments on this form of escape: —

For many buildings, such as hotels, dormitories, apartment houses and dwellings, individual types of fire escapes are frequently needed, so that persons can escape from rooms without having to pass into halls leading to usual means of exit or to fire escapes. It is recognized that flames issuing from wall openings below may prevent the use of such escapes.

A rope is the simplest and least expensive form of individual escape. It has, however, questionable value. It takes strength and experience to lower one's self several stories, and ropes are practically valueless for women and children unless they are tied around the body and some one else lowers the person in question.

A rope if used should have a diameter of about 1 inch and be firmly and permanently secured.

Rolled steel cable ladders with rigid rungs have had some use. They are better than ropes, because there is less danger of falling, but it takes skill to climb such a ladder, which generally swings considerably when used. Only substantial ladders, and those which are designed to keep the rungs a reasonable distance from the building wall, are advisable.

Unquestionably the best type of individual escape is one which will lower a person or persons at a uniform and moderate rate of speed, without any action on the part of the occupant of the broad belt which is usually placed under the arms. (See Fig. 3, Page 33.) Speed controlled by adjusting friction on a rope sliding through the hands is objectionable, because not easily understood, and also because bad falls may result from overspeed. Automatic speed regulation is necessary.

As fire occasionally breaks out under the windows which would ordinarily be used by such a portable escape, it is good policy to arrange the escapes so that they can be moved to any one of several windows.*

Poles

In some plants in which an exceedingly rapid spread of fire is feared, and where few men are employed, a sliding pole such as those used in fire department houses has been employed as a means of exit. (See Fig. 1, Page 33.) Adequate platforms leading to poles are necessary and poles must be kept in good condition. Obviously, men must be drilled in their use. A landing pad should be provided at the foot of such poles.

Capacity of Exits

In order to bring about safe exit conditions in a given building, either one of two alternative arrangements may be adopted: —

(1) The maximum number of persons permitted in the building may be limited in accordance with the existing capacity.

(2) Sufficient exit capacity may be provided to accommodate the desired number of occupants, where the latter is in excess of the existing capacity.†

The necessity for regulations along these lines is being recognized in the rules and legislative requirements of a number of states. This is notably true of the New York State Laws of 1913, which are followed, to a considerable extent, in the following discussion.

The Time Element

The capacity of a single stairway is unlimited, provided there is unlimited time available

* One of the best types of individual escapes on the market is made of wire cable, covered with an insulating material which thoroughly protects it from fire. It also has a belt at either end, so it can be used repeatedly without re-winding.

† Sometimes radical changes are made in the nature of the work or in the number of employees in a given building, so that exit facilities which were originally satisfactory are rendered insufficient. This makes it necessary to re-consider the question of exits at intervals, particularly whenever a radical change in the building occupancy is made.

for its use. In case of serious fires, however, the time available for escape is *not* unlimited, as has been amply proven by many disasters. (See Page 21.) It should accordingly be possible to empty all rooms which may be subjected to a single fire, within a reasonable period of time after a fire is discovered. What constitutes a "reasonable" period of time will vary, chiefly in proportion to the speed with which a fire may spread. This is determined by the character of the building construction (fire-resisting, mill, frame, etc.), and by the nature of the processes carried on in the building, or in other words, the "hazard of occupancy." It should be possible, however, to empty the ordinary building in not more than three minutes, as mentioned later.

Hazard of Occupancy

The hazard from fire and panic is obviously greater where inflammable materials are used in the working process, than where such materials are not present.* It is greater also where women are employed, than where there are men only. The congestion and crowding which are incident to certain industries add to the panic hazard.

These features accordingly have a direct bearing on the time which should reasonably be required to empty a given building. In other words, the variation in the fire and panic hazard of different industries justifies a corresponding variation in the required exit capacity. In order to introduce this distinction, industries may be divided into three general groups, as has been done by Mr. Carl M. Hansen in his "Universal Analytic Rating Schedule."

> "A" industries are those having a relatively low fire and panic hazard, such as machine shops and metal-working industries.
>
> "C" industries are those having a relatively high fire and panic hazard such as processes involving the use of gasolene or celluloid, cotton goods manufacturing, laundries, etc.
>
> "B" industries represent those lying midway between these extremes, such as the leather, woolen and woodworking industries.
>
> (See "Exit Capacity Schedule.")

Space Requirement

In estimating the capacity of a given form of exit, the best method is to consider it in units of 22″ in width, each unit representing a line of persons in single file.

It is possible for persons of average size to travel in a space 18″ in width, that is, two columns in a 36″ stairway. As has been pointed out by Mr. H. F. J. Porter, however, there is danger of three persons jamming or arching across a 36″ stairway and stopping the progress entirely.† As stairways are widened beyond 36″ the arch formed by three bodies becomes flatter, until, at about 44″, it breaks down through the centre and releases the jam. 44″ (or higher multiples of 22″), is accordingly recommended as the standard width of stairways, exit doors, etc.

Obviously the capacity of a given stairway is not increased by widening it a few inches, unless the added width is sufficient to permit an additional line of persons to travel down it. (Some of our State and Municipal laws are illogical, in that they increase the capacity allowance of stairways, for small increases in the width which will not enable any more persons to use the stairway in a given time.)

In moving down a stairway each person requires the constant use of two treads. Since stair risers are commonly about 8″ in height, this means that about one and one-third feet of vertical distance is required per person on a stairway. In other words, a stairway between

* In the case of the Triangle Shirtwaist Factory (Asch Building) fire, the fire spread so rapidly that a number of the operatives were overcome before they could extricate themselves from the aisles near the machines. The rapid spread of flames was due to inflammable material, such as cotton, lace, and other trimmings for fancy shirtwaists in the process of manufacture. (See report of the New York Board of Fire Underwriters, April 4th, 1911.)

† See report to New York State Factory Investigating Commission, 1912. A case is cited occurring at 548 Broadway, New York, on May 5th, 1911, in which the occupants of one of the floors of a loft building became frightened by an alarm of fire. They rushed to the narrow wooden stairway, where a jam occurred which burst the railing. Many persons were thrown to the landing below, two girls being killed and several others seriously injured.

twelve-foot stories of a building would accommodate nine persons. The landings will accommodate some persons in addition to those actually on the stairs.

In buildings more than two stories in height, persons from the upper floors attempting to use a continuous stairway will find their passage blocked by those from the floors below. It accordingly follows that to insure thorough safety in a building, there should be sufficient stair capacity to accommodate all the persons on a given floor within smoke-proof towers or cut-off stair shafts directly available for the use of that floor, without any forward movement.

This is recommended as a standard for the most hazardous type of building construction and occupancy.

It is safe to assume, however, that there will be some progress down the stairways, under ordinary conditions; so, for the better types of construction and less hazardous manufacturing processes, the exit capacity rating may be safely increased.*

With these principles in mind the following table is proposed as an approximate method of rating the relative value of different types of exits, and calculating the permissible number of persons on a given floor: —

Width of Exit Capacity, in the table opposite, should be determined by measuring the horizontal width of doors in fire walls or fire-resisting partitions, width of stairways, between handrails in open stairs and from face to face of walls without considering handrails in enclosed stairways (except circular stairways or "winders," for which see below). For outside stairs or fire escapes, the width of stairway, or of doors or passageways leading to stairway, whichever is least, should be taken.

The capacities given are based on 22″ width of exit capacity; for 44″ the figures should be doubled; for 66″ they should be trebled, etc.†

EXIT CAPACITY SCHEDULE

Exit (for specifications, see "Types of Exits"	*Persons per 22″ width of exit capacity in buildings of the following construction and occupancy **				
	Fire-res. A.	*Fire-res. B Mill A*	*Fire-res. C. Mill B Frame A*	*Mill C Frame B*	*Frame C*
Door in Fire Wall or Fire-Resistive Partition	100	85	70	60	50
Smoke - Proof Stair Tower Protected Bridge or Balcony	20	17	14	12	10
Cut-off Stair Shaft Unprotected Balcony or Bridge Outside Stair or Protected Fire Escape Straight Chute	15	12	10	9	8
Semi-enclosed or Unenclosed Stairway Unprotected Fire Escape Spiral Chute	10	8	7	6	5

* For significance of letters A, B, and C, see "Hazard of Occupancy."

In all cases there must be a continuous unobstructed passageway from point where employees leave floor on which they are employed, to ground or other safe discharge point. Where there is any narrowing of the passageway or stairway between workroom and discharge point (which is undesirable), the allowance of exit capacity should not be greater than the width of such passageway or stairway at its narrowest point.

Winders or Circular Stairways are decidedly unsatisfactory as a means of egress. (See "Circular Stairways," Chapter 10.) In measuring the width of circular stairs or stairs containing winders, for capacity, that portion of the tread which is less than 8″ in width should be disregarded. It is further suggested that the capacity rating given above be reduced 10% for each story, with a maximum reduction of 90%, wherever 30% or more of the stair treads are of winder type.

Test of Exit Capacity. Obviously the length of time required to empty a building of its occupants varies, not only with the physical condi-

* Observations show that persons can descend stairs at the rate of about 1′ per second for several stories. For high buildings the speed naturally decreases.

† The New York laws already referred to make a distinction in exit capacity allowances for new and old buildings. For new buildings the standard of width is 22″, and for old it is 18″. This would seem to be a reasonable concession to existing conditions which are largely fixed.

tions of each particular risk (arrangement of aisles, machines, etc.), but also with the degree of facility shown by the occupants in leaving the building.

It accordingly follows that one of the best methods for determining whether or not the exit capacity of an existing building is adequate, is to make an actual emptying test or fire drill. (See Chapter 41.)

Where the building or its equipment is readily combustible, it should be possible to remove all occupants in two, or at most three minutes, from the time a fire is discovered.

Such a test, however, merely measures the capacity of exits and does not indicate whether or not they are properly protected from fire. This feature can only be determined by competent inspection.

Effect of Automatic Sprinklers on Exit Capacity

In approximately 95% of all fires in sprinkled buildings, the fire has been either extinguished or held in check by the sprinklers. (See Chapter 40.)

In view of the large reduction in hazard which is thus effected, it would appear entirely reasonable to allow an increase of 50% in the number of occupants which would otherwise be permitted by the exit capacity of a given building, for an approved installation of automatic sprinklers, as has been done in the New York law already referred to.

CHAPTER 7

COLLAPSE OR FAILURE OF BUILDING STRUCTURE

THE collapse or failure of buildings is relatively infrequent, but some serious accidents of this kind have occurred. The principal causes of such accidents are, — Improper Design, Faulty Construction, Overloading, Deterioration on account of vibration, age, etc., and Collapse while changes in foundations or structural parts are under way. These causes, either singly or in combination, are responsible for most of the building failures involving loss of life.

IMPROPER DESIGN

There is little excuse for accidents from improper design, and the way to avoid them is obvious; the properties of various materials, as well as their proper application to building construction, have been well determined and recorded. This information is available for the architect in various engineering handbooks.

FAULTY CONSTRUCTION

The dangers of Faulty Construction can only be guarded against by careful selection of materials, and thorough inspection by a competent person while the building is being erected.

The desire to keep down the cost of a building to the minimum, and to complete construction quickly so as to realize on the investment, if often responsible for dangerous haste and high pressure in carrying on the work.* Such haste is liable to interfere with the proper care needed to secure first-class construction of any type; it also makes difficult the correction of defects, when discovered, on account of the delay which such changes would occasion. It is especially liable to have disastrous results in the case of

Reinforced Concrete

Many serious accidents are on record where forms have been removed from concrete before it had time to harden properly, or where the work was carried on in cold weather without proper precautions against freezing. The following cases may be mentioned as characteristic examples of such failures: —

Four men were caught and seriously injured in the collapse of a re-inforced concrete building at a plant in Etna, Pa., on Feb. 19th, 1912. The building was 100′ wide by approximately 467′ long, principally two story, with an 80′ section three stories in height. Appearances indicated that the roof failed, carrying with it the second and third floors to the ground; fortunately sufficient warning noises occurred to permit the escape of most of the workmen. The failure occurred about a month after the concrete had been poured, but continuous cold weather had intervened, and the broken concrete was found to be wet, soft and mushy in some places, and the interior portion of large sections showed small crystals of ice.

Subsequent examination indicated that the design was satisfactory; the failure was due to freezing of the mixture while it was still wet, and subsequent thawing after the forms were removed. (See "Engineering News," Feb. 29th, 1912.)

A foreman was killed and two other men slightly injured on April 7th, 1910, by the collapse of a concrete roof on a new car house at Saybrook, Conn.; the building was 79 x 194′ in size. Work on the roof had been completed about 10 days previously and the supports were removed; the main part failed first, other panels giving way successively. The cause of the collapse is given as "premature removal of the forms; also, excessive loading of the green roof with roofing material."

Four men were killed and seven others injured by the collapse of a four story building under construction in Cleveland, on November 22nd, 1910. The building was nearly completed, and "evidence tended to show that concrete was green and not thoroughly set when forms were removed."

* See "Efficiency versus Faulty Construction," Chapter 10, Fire Prevention and Fire Protection, Freitag.

Defects in workmanship, failure of fresh concrete, and freezing, are all mentioned as causes of accidents from concrete chimneys, in an article by Mr. Sanford E. Thomson in "Engineering News" for Jan. 9, 1908. Serious loss of life is liable to result from the failure of a tall chimney, and the incidental crushing and wrecking of adjacent buildings.

In addition to precautions to avoid accidents from such conditions, it is very important to get an even mixture of the material, where concrete work is being done. For this purpose mechanical mixing is preferable to hand mixing.

OVERLOADING

Overloading of floors or other parts of a building structure may occur through the installation of machinery, tanks, or other fixtures which are too heavy to give an adequate factor of safety for the members which must carry the load; or through the accumulation of heavy stock of material during the ordinary course of manufacture.

The first of these causes is largely a question of proper engineering at the time new equipment is installed, although a factor of safety which was at first adequate, may be reduced through subsequent deterioration of the supporting members.

In many lines of manufacture the materials handled are so light that there is little danger of floors being overloaded; where heavy materials are stored or used, it is desirable, so far as practicable, to confine them to first or ground floor occupancy. Where such materials are necessarily handled above the first floor, constant inspection and supervision may be necessary to avoid dangerous loads.

An accident which illustrates the necessity for such care, occurred at a cracker factory in Cleveland, Ohio, on March 1st, 1902. The fourth floor gave way and crashed through the three lower floors to the basement, carrying with it twelve women and three men; four of the women and one man were killed, and thirteen other occupants of the building were injured.

The immediate cause of the accident was given as overloading of the top floor with flour; testimony at the coroner's inquest was to the effect that girls working in the icing department on this floor had complained to the foreman, on several occasions, of the floor cracking when heavily loaded trucks were run over it, but that no attention was paid to their complaints. As having a further bearing on this accident, it is mentioned in the coroner's verdict, that the planks which composed the girders were only spiked together, no bolts being used, and that dowel pins were not provided for the column caps. It would thus appear that improper construction also entered into the causes of this accident.

One of the most serious catastrophes in recent years resulting from overloading of floors and subsequent building collapse, was that of the Herald Building, Montreal, Canada, occurring June 13th, 1910. (See Fig. 3, Page 47.) After the collapse the building took fire. In addition to thirty-two people being killed, the property loss amounted to $153,000 for the Herald Building and $17,000 for adjoining buildings.

Water Tanks. (For illustrations of tank failures, see Page 47.)

A relatively frequent cause of building collapse is found in the location of water tanks over buildings. Such tanks are often used for sprinkler supply, or for the ordinary mill service. The following information, obtained by writing to various plants where tank accidents had occurred, is of interest as illustrating the principal causes and results of tank failures:—

At least ten persons were killed and fifty-nine injured as a direct result of these failures, in fifty-six cases where information on this point was obtainable. Property damage in thirty cases reported average almost $12,000 per case.

The largest number of accidents in any one division, nearly 30% of the total, occurred from the corrosion of flat hoops, indicating the importance of using round hoops only. In several instances an inspection shortly prior to the accident failed to disclose weakness in the hoops, as the corrosion occurred underneath, where it was invisible.

Fig. 1. Tank Failure.

Fig. 2. Tank Failure.*

The common practice of placing water tanks over buildings has resulted in many catastrophes, involving extensive property damage as well as loss of human life.

Figs. 1, 2, and 4 each illustrate a building which was wrecked by a falling water tank, and give a graphic idea of the destruction which may result in such cases.

Fig. 3 shows a building just after the floors collapsed, causing the loss of thirty-two lives. While there was a water tank on this building, the evidence showed quite conclusively that overloading of floors and vibration of heavy printing machinery were the causes of failure. The building was about forty years old and had previously given signs of inadequate strength, having been shored up and re-inforced on several occasions.

Fig. 3. Building Collapse.

Fig. 4. Tank Failure.*

* Courtesy of Canadian Fire Underwriters Association.

DATA NO 63 CASES OCCURRING IN THE UNITED STATES AND CANADA BETWEEN 1900 AND 1913*

Tanks located over building in 53 cases.
Persons injured in 15 collapses (56 cases reported) — 59.
Persons killed in 8 collapses (56 cases reported) — 10.
Property damage in 30 cases reported, — $350,000.
Tanks new to 17 years old; capacity 5,000 to 50,000 gals.
Collapses occurring out of working hours in 12 cases reported, — 9.

Number of Collapses	*Cause*	*Age*	*Remarks*
19	Corrosion of Flat Hoops	Two — 6 yrs. old Two — 8–9 yrs. Four — 10–12 yrs. Two—15–17 yrs.	Age of others not given
7	Poor design of supporting structure	Four — new	Age of others not given but probably new
9	Weak building walls supporting tank	Four — new Others not given	Bldg. walls undermined in 4 cases
4	Poor workmanship in erecting	Three — new Others not given	One, — poor bracing during repairs
3	Use of defective materials	One — new Two — 15 yrs. old	
6	Corrosion of metal or rotting of timber supports	One — 5 yrs. old One — 9 " " Others not given	Five collapses caused by decay of wood timbers
3	Supports weakened by fire	Not given	
3	Storms	One — 9 yrs. old Others not given	One, — Telephone wires on tank contracting in cold weather
2	Overloading of building floors	Not given	Not properly tank failures
7	Unknown	Not given	

*Re-printed from an article by the author in the N. F. P. A. Quarterly for July, 1914.

The erection of tanks on building walls which were not sufficiently strong to support them was another serious cause of failure. This, together with poor design of supporting structure, indicates that the "human element" is probably the most prominent factor in the occurrence of tank failures. The surprisingly large number of twelve cases out of a total of twenty-seven in which the age was given, were *new* tanks just *being filled for the first time!*

Three cases were caused by storms, but the percentage of failures from this and other natural causes which could not reasonably be anticipated is notably small. If the nineteen cases due to corrosion of flat hoops (which might have been avoided by substituting round ones) are included in the "preventable" class, considerably more than half of the total loss could have been avoided by the adoption of proper precautions.

The Vice President of one of the plants which was wrecked by a falling tank, expressed himself as follows: — "This was one of the most disagreeable experiences of the writer's business career. Had the collapse taken place during the daytime, it would have killed somebody on the top floor and created a panic on the next floor beneath where about two hundred girls were working, and it makes me shudder now to think of the consequences. I never see a tank on the top of a building but I want to tell the manager my experience."

It would be well indeed if other managers could profit by this experience and see that every precaution is taken for the safe construction and maintenance of their overhead tanks, without waiting until the lesson is repeated in their own plants. These precautions should be along the following lines: —

1. Careful checking of design of tank.
2. " " " strength of supports.
3. Thorough and competent supervision of materials used, and workmanship during erection.
4. Use of round hoops only.
5. Periodic inspections for corrosion, decay, etc.
6. Periodic paintings for reducing such corrosion and decay.

Twenty thousand gallons of water weighs approximately 83 tons. If it is located 20 feet above the roof, and falls, it strikes the building with a force of 1,666,000 foot-pounds. This is equivalent to a 50-ton locomotive going at the rate of 32 miles per hour, so it is not surprising that such an accident may completely wreck a large and apparently strong building.

DETERIORATION

Deterioration of buildings from the effect of age is a slow process, where the building is well constructed, of good materials. When steel skeletons are used, the steel suffers practically no deterioration provided it is properly protected, so far as present experience shows.

The results of earlier forms of iron and steel construction have been carefully observed where buildings were being demolished, and such records are available for varying periods up to fifty years (see "Condition of Iron and Steel found in torn down buildings," Fire Prevention and Fire Protection, Feitag, p. 273.)

Since the modern type of steel construction is of comparatively recent development, it is not possible to obtain records at the present time of greater length of service than this. In the case of brick buildings, however, much longer periods are available. The following brick and wood buildings in Boston are still in a state of good preservation after lengths of service varying from 150 to 200 years.

Old State House *	1713
Old North Church	1723
Old South Church	1729
Kings Chapel	1749
Faneuil Hall	1763

* Burned in 1748, but old walls used in rebuilding it in 1749.

Regular religious services are still held in two of these churches, the other, as well as the Old State House, being used for exhibition purposes; Faneuil Hall is occupied as a market house. It will thus be seen that they are all suitable for occupancy at the present time, notwithstanding their great age.

Where buildings are wholly of wood, the rate of deterioration varies exceedingly, and is dependent upon suitable protection from the weather, moisture, etc., as well as upon the quality and nature of the wood used. There are a number of frame houses in this country from one hundred and fifty to two hundred years old, which are still well preserved. For example, — the Longfellow house in Cambridge, built in 1759; the Wadsworth house in Cambridge, built in 1726; the Rebecca Nourse house in Danvers (stated to be the oldest frame building in New England), built in 1636.

The factor which is most liable to materially reduce the life of a frame building, or of a building constructed with wood columns, floors, etc., is that known as "dry rot."

Dry Rot. Dry rot has caused serious loss in a number of factories, requiring extensive repairs or replacements in buildings where it had affected the woodwork. Two prominent examples of recent years may be mentioned as showing the danger from this cause.

In an article published in "Engineering News" for December 2, 1909, Prof. Ira H. Woolson describes the failure of the Gled Hill Wall Paper Company's plant in New York City. After a fire which was soon under control, the floors began to fall in irregular sections and the entire building, a six-story structure 50 to 75 feet wide by 200 feet long, was soon a mass of débris.

Examination showed that the timber posts, some of which were of oak and some of long-leafed yellow pine, were greatly weakened by dry rot. The affected portions burned rapidly so that some of the fourteen- and fifteen-inch oak columns were completely burned off, and in other places holes were burned into the interior of the timbers, leaving the outer shell of sound wood. The timber was only partially seasoned when put in place, and socket caps on the ends of the columns prevented any circulation of air. From the condition of the timbers, it is probable that the building would have collapsed if subjected to a concentrated load on any floor, independent of the fire.

A second case is described in an article by F. J. Hoxie and C. H. Smith in "Engineering News" for December 21st, 1911. This relates to a mill of the Canadian Spool Cotton Company in Quebec, where the entire wooden frame of the building was replaced by steel, on account of dry rot, although the mill had been put up less than four years previously.

The first defect was noticed less than two years after erection, from the floors settling, due to the crushing of the three-inch blocks between the posts of each story. When preparations were made to replace the blocks it was shown that the columns were also affected: the process of decay had gone so far that it was necessary to replace the columns. The specifications for this lumber called for long-leafed yellow pine, but it is probable that an inferior grade was furnished; the lumber lay on the ground the previous winter, which undoubtedly accounted for its infection.

The good grades of long-leafed pine are largely immune from attack, but this timber has now become so scarce that it can hardly be obtained. In its place is being substituted Cuban or "loblolly" pine, much of which is particularly susceptible to dry rot. (See Figs. 1–3, P. 51.) This means that the hazard from this source is one which is constantly increasing, and it is accordingly of special importance that the danger be recognized, and all reasonable precautions taken to avoid it; otherwise, serious loss of life and property are sure to result.

Dry rot may be started in sound timbers by contagion, much as human diseases are transmitted, through contact with a piece of affected timber or with affected earth. Dry rot spores, which are infinitesimally small, may be carried long distances floating in the air. Small pieces broken from the plants may also start an independent growth. The ground in lumber yards is likely to become saturated with the dry rot fungus, which is thus contributed to successive piles of fresh lumber; even though the fungus is thoroughly dried, it rapidly assumes a vigorous growth when subjected to suitable conditions of moisture, etc. (See Fig. 7, P. 51.)

Since dry rot usually works from the interior, it is difficult to detect from the outside; a wooden member may present a good appearance externally until its strength is far gone and only a thin shell of sound wood remains. Noticeable deflection of a beam is likely to occur, however, before ultimate failure results. For example, it may be difficult to keep the shafting in alignment in an affected mill, and where any unusual condition of this sort is noticed a careful examination for dry rot should be made. This can be determined by drilling into the member with a small bit ($\frac{1}{2}''$ or less in size). Hammer tests may also be of value in detecting unsound timber.

An exhaustive study of this entire subject has been made by Mr. F. J. Hoxie, engineer and special inspector of the Associated Factory Mutual Fire Insurance Companies. The latter body has published an interesting booklet on the subject containing more than 100 pages, entitled "Dry Rot in Factory Timbers," from which the following paragraphs in quotation have been reprinted.

Mr. Hoxie has shown that the rosin in pine timber acts as a preventive of dry rot, and the resistance of a given piece of wood varies with the percentage of rosin it contains. (See Figs. 1 and 6, P. 51.) It accordingly follows that this is an important factor in determining the suitability of lumber for use in building construction. After commenting on the confusion in nomenclature and specifications, and the difficulty of determining the different species of pine from any ordinary inspection, Mr. Hoxie gives the following suggestion for a specification, based on rosin and density.

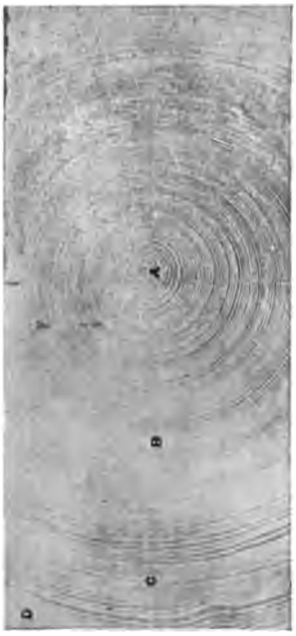


Fig. 1.* Long-Leaf Pine.

Fig. 2.* Cuban Pine.

Fig. 3.* "Loblolly" Pine.

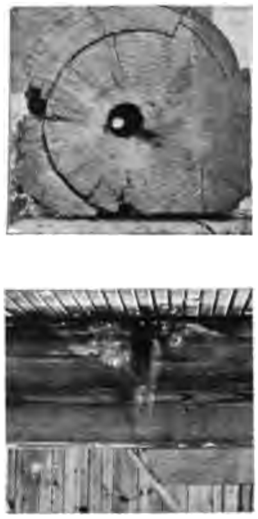


Fig. 4.* (a) Section of bored pine column, affected by dry rot.
(b) Fungus growing between double beams, front beam having been removed.

These photographs show 8″ x 18″ sections, Figs. 2 and 3 being affected by dry rot. Distribution of rosin in Fig. 1, — (A) 25%, (B) 14%, (C) 17%, (D) (sap wood) 3%.

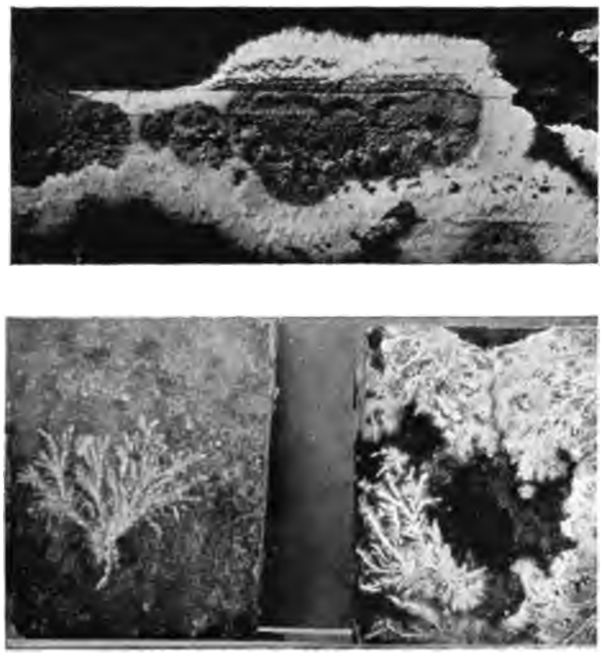


Fig. 5.* (a) "Merulius Lacrymans," or Dry Rot with fruit.
(b) Sterile Dry Rot plants as commonly seen.

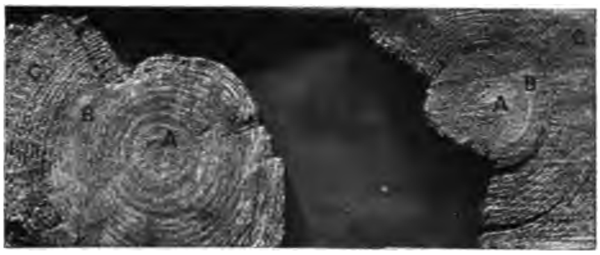


Fig. 6.* Effect of Rosin in resisting Dry Rot, — the distribution being as follows: — (A) 5%–29%, (B) 7%–12%, (C) .68–.88%.

Fig. 7.* Concrete Lumber Supports, to prevent contact with earth affected by dry rot.

* Courtesy of Associated Factory Mutual Fire Insurance Companies.

"The ideal specification is undoubtedly a clear description of the qualities required. In structural timber these are strength and durability. With these qualities defined, attributes such as botanical variety, location of growth or grading, lose their importance. The limits of strength can be easily given but are less easily determined without destroying the material. The density is a sufficiently close index of strength for commercial purposes. From all information thus far available, the percentage of rosin is the most reliable index of durability for the southern pines.

Both the rosin content and the density can be conveniently found by boring one inch holes 2″ deep into the end of the beam, collecting the chips, drying and weighing them, then extracting the rosin from them with benzole and weighing it. Cuban or North Carolina pine with 10% of rosin is apparently as resistant to fungus as longleaf pine with the same percentage. Heart without rosin is not immune.

It is apparent that the limiting amount of rosin which is just sufficient to stop the fungus is in the neighborhood of three per cent. The limiting power of rosin is undoubtedly not absolute but varies with the moisture, variety of fungus and time of exposure. Therefore, it is safe to assume that a mill beam should have four or five per cent of rosin throughout to successfully withstand fungus from its own power of resistance under ordinary conditions of dampness, allowing a factor of safety of about two. Dye houses and paper mills would probably require more.

Specifications

The following suggestions for specifications are offered for use when Southern pine timber of an excellent quality is required.

Density. No part of the material shall have a density of less than thirty pounds per cubic foot when tested by boring smooth holes one inch in diameter and two inches deep in the ends of the stick, drying to constant weight at 212° F. and weighing the borings and computing the density from the volume of the hole.

Rosin. None of the heartwood shall show less than 4 per cent of rosin by weight when borings are taken with a one inch bit with a hole two inches deep dried to constant weight at 212° F., and extracted with benzole, the extracted rosin evaporated until it is not soft or sticky when touched with the finger at 70° F.

Heartwood. Heartwood shall show in all four faces of every stick, and sapwood shall not extend more than two inches from the corner at any place, measured perpendicularly to the corner across the face.

Defects. No timber with knots greater than one inch in diameter, or rot or injurious shakes will be accepted.

Branding. Longleaf pine sold under this specification shall be branded with the letters 'F. M.,' with the name of the lumber manufacturer, the location of the saw-mill from which it comes, and the date of sawing, in letters at least one inch high.

Ventilation is generally the first preventive measure suggested. Dry wood which is kept dry is undoubtedly incapable of fungus infection, but ventilation does not necessarily cause drying. The wood will come into equilibrium with the moisture in the air and will become dryer or wetter in proportion to the relative humidity. Therefore timber ventilated with moist air will have its rate of rotting accelerated if it is a susceptible variety. Moreover the susceptible varieties absorb moisture more rapidly than those which are more resistant.

A heavy coat of paint may accelerate or retard the rate of rotting, depending upon whether it prevents wood from absorbing or giving up moisture. The question of primary importance is whether the wood is resistant or susceptible."

There has been considerable discussion as to the effectiveness of boring timber for ventilating purposes, with the idea of reducing its susceptibility to dry rot. It appears, however, that this is of little or no value, and the consensus of opinion of seven prominent engineers, as expressed in letters to the editor of the "Engineering Record" (March 12th, 1910) is against this practice. Mr. Hoxie comments on this phase of the subject as follows: —

"Undoubtedly columns with holes through them and thinner beams would dry quicker if given a chance to season, but the common custom of boring green or wet columns just before they are put in place in the building, and using moist lumber for double beams, leaves ideal places for the growth of fungus, as the air in the openings is saturated with moisture. The holes in the columns have the additional objection of forming a convenient passageway for the fungus to pass rapidly from floor to floor before the building has dried out. [See Fig. 4, P. 51.] Untreated Carolina pine used for interflooring sometimes serves not only to infect the mill but to carry the infection to all susceptible beams or planking in the floor."

In boring timbers there is the further difficulty of properly centring the tool in large pieces; the grain of the wood is likely to carry the tool off centre, so that the two holes do not meet in the middle of the column, and this may cause warping or deflection of the member.

It is difficult to stop the progress of dry rot after the timbers of a building are once seriously affected. Mr. Hoxie mentions a case where the thorough heating of a mill was tried at his suggestion. This was repeated four times at about 115° F. by turning on the steam in warm weather from Saturday noon until Monday morning, the temperature being carefully regulated to prevent injuring the sprinkler heads. Samples which were tested later showed this method to have been quite effective in checking general progress of the fungus, although it did not sterilize the window frames, hollow roof and ends of beams embedded in the wall.

Where dry rot has made considerable progress the only sure method for stopping it seems to be the removal of affected timbers, and sterilization of adjacent woodwork or masonry.

Mr. Hoxie discusses the antiseptic treatment of building material before it is put into the structure. Creosote or Corrosive Sublimate both seem to give good results. The black greasy appearance of Creosote and its unpleasant odor make it rather unsatisfactory for use in factories. Creosote also tends to increase the inflammability of the wood. Corrosive Sublimate is quite poisonous and must be handled with great care.

Mr. Hoxie states that the cost of antiseptic treatment is not prohibitive, prices quoted by treating companies varying from eight dollars to fifteen dollars per thousand feet, board measure. He believes that by thorough treatment of good Cuban or North Carolina pine immediately after it has been sawed and before it has had opportunity to become infected, satisfactory material for "slow-burning" or mill construction can still be obtained at a reasonable cost.

For a thorough discussion of various phases of the dry rot problem, see Mr. Hoxie's booklet, "Dry Rot in Factory Timbers," which may be obtained from the Associated Factory Mutual Fire Insurance Companies, 31 Milk St., Boston.

VIBRATION

The adverse effect of vibration in a building is so obvious as to need little discussion. A common cause of vibration is found in the location of heavy machinery or drives on upper floors. Unless the building has been especially designed for such use, this practice is dangerous and should not be permitted. Continued vibration is liable to start progressive fractures in iron or steel work. (See Chapter 16.) Where noticeable vibration of a building exists, a competent architect should be consulted.

COLLAPSE WHILE RECONSTRUCTION IS UNDER WAY

Many accidents which have resulted from buildings collapsing while changes in them or adjacent buildings were under way, show the necessity for great care in carrying on this kind of work. The following examples may be cited: —

On July 15th, 1909, a building in Philadelphia collapsed causing the death of nine workmen and injuring many others. It was a five-story structure, brick and timber, about 20 by 100 feet. Reconstruction work was going on, consisting in the removal of a previous second floor so as to make one large exhibition room of the two first stories.

On August 8th, 1905, a dry goods store in Albany, New York, collapsed while alterations in the sub-basement were under way, involving the undermining of some walls and columns. Thirteen persons were killed and many injured. The accident happened at nine o'clock in the morning, or the list of killed and injured would probably have been much larger. The building was three stories in height and the center portion of it collapsed.

In this particular case, sufficient warning was given by the settling of a floor and dust falling from the ceilings, to have emptied the building if the seriousness of the situation had been realized; these signs were noticed five or ten minutes before the collapse occurred, and one of the officials had summoned the foreman in charge of the work to an upper floor to advise him to be more careful.

Those fatally injured were all employees of the store; the workmen in the basement saw sufficient evidence of the coming collapse to escape to the street. Investigation showed that the footing of three columns had failed on account of a lateral crushing out of the earth underneath them, due to settling of the clay. This building was composed of reconstructed dwellings, and apparently no adequate investigation of the condition of foundations, etc., had been made. (See "Engineering News," Sept. 14th, 1905.)

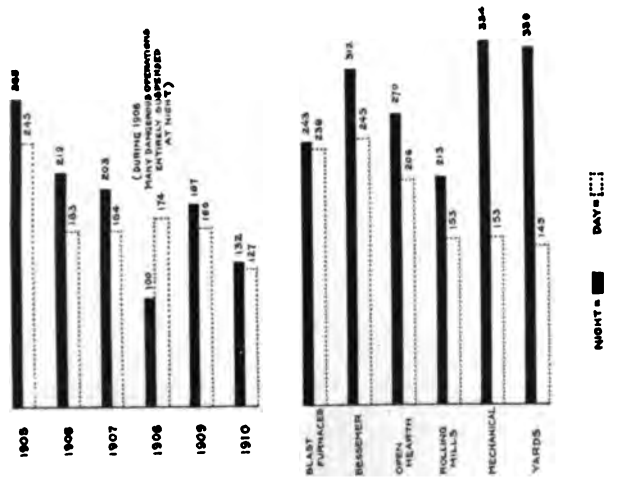
CHAPTER 8

LIGHTING

EFFECT UPON ACCIDENTS

THAT adequate light is an important factor in the prevention of accidents may be assumed as self-evident, but there is really no absolute way of proving it. This proof has been attempted by a comparison of accidents in the summer and winter months; because certain tables of statistics show fewer accidents in summer than in winter, it has been assumed that the difference is due to the greater prevalence of daylight in summer. This conclusion is scarcely permissible, since the benumbing effect of cold weather furnishes quite as reasonable an explanation for the increased accidents in winter, as does inadequate light.

More accurate results could probably be obtained by a comparison of accidents per thousand workers on day and night shifts, since the lighting at night is generally inferior to that during the daytime. While such comparisons do not always give uniform results, the following chart may be taken as fairly characteristic, and it indicates a somewhat higher proportion of accidents during the night shift.



DAY AND NIGHT ACCIDENT RATES PER 1,000 300-DAY WORKERS IN LARGE STEEL PLANT, BY YEARS AND DEPARTMENTS, 1905 TO 1910

COPIED, BY PERMISSION, FROM U.S. SENATE DOCUMENT 110 "CONDITIONS OF EMPLOYMENT IN THE IRON & STEEL INDUSTRY"

Another interesting point which may be gained from a study of this table is the greater uniformity of accidents between day and night turns during the later years; this is undoubtedly due to better illumination having been introduced, as improved lighting equipment was perfected. (Flaming arcs, tungstens, etc., replacing the old type open arc.) This would seem to indicate that there had been a direct reduction in the night accidents, as compared with those which occurred during the day, chiefly on account of improved illumination.

CHARACTER OF ILLUMINATION

In treating the subject of illumination, two forms of light must be considered, viz., natural and artificial. From the standpoint of safety, there are two undesirable features common to both these sources of light, which should be avoided so far as possible, — (1) Undue Brilliancy or "Glare" and (2) Heavy Shadows.

Nervous strain and gradual impairment of vision may result from the effort to adjust the eye to great contrasts of light and shadow; there is also constant danger of employees falling over obstructions or being caught in machinery, where the light is so bright as to have a dazzling effect or so dim as to make objects indistinct.

Glare. The following analysis by Prof. L. Webber ["The Illuminating Engineer," Vol. 3 (1910), Page 116] describes in good terms the factors which may cause glare: —

"A system of illumination may be described as 'glaring' when it exceeds any of the limits specified in the following, namely: —

(*a*) If the ratio of the intrinsic brilliancy* of the

* "Intrinsic Brilliancy" is a term used to designate the surface brightness of a given source of light; an idea of its variation may be obtained from the following comparison. (See "Standard Handbook for Electrical Engineers," Louis Bell.)

Intrinsic Brilliancy of Sun	500,000 to 600,000	c.p. per sq. in.
Open Arc	10,000 to 100,000	" " "
Gas-filled Tungsten	8,000	" " "
Tungsten filament	1,000	" " "
Carbon filament	100 to 500 to 1,000	" " "
Mercury Arc	10 to 13	" " "
Open gas flame	4 to 8	" " "
Candle	2.5	" " "
Moon	2.0	" " "

source of light to that of the illuminated surroundings exceeds a certain limit. This ratio should not exceed a value of about 100.

(b) If the absolute intrinsic brilliancy of the source exceeds a certain value. The brilliancy of the open candle flame (about 2.5 candles per square inch) might be taken as a safe limit.

(c) If the angle between the direction of vision of the eye when applied to the work it is called upon to do (e.g., when gazing at a desk, blackboard, diagram on the wall, etc.), and the line from the eye to the source of light, is too small. This minimum angle may be provisionally assumed to be 30°.

(d) When the extent (apparent area) of the illuminating body is too large. The source should not subtend an angle of more than 5° at the eye."

In other words, — the source of light should not be too powerful in comparison with its surroundings, or from the absolute standpoint, and it should not have too great an area. There is a range beyond which the eye should not be required to adjust itself, hence the need of some such limitations as those outlined above.

It is also apparent that the angle between the source of light and the line of working vision should be large enough to avoid the strain resulting from a constant effort to adjust the retina of the eye to suit two conditions which are so radically different, namely, the brilliant source of the light itself, and the surface of the work which can only reflect a fractional part of this light.

HEAVY SHADOWS

These may be avoided by having the sources of light (windows or lamps) distributed as evenly as possible, and by making adequate provision for diffusing the light throughout the room. (See Pages 57 and 59.)

This diffusion is best effected by having the walls, ceilings, columns, etc., light in color, either through the materials of construction or by the addition of paint or whitewash as needed. The diffusion of light may be further improved by the use of prismatic or ribbed glass in windows, and by suitable shades or reflectors on the lights.

Shadows have a certain value in assisting the eye to gage distance and direction. While it might be possible, theoretically, to secure too even lighting, there is little danger of this in actual practice; the common difficulty is too little, not too much, diffusion.

In applying these principles to actual conditions, the following points should be kept in mind.

NATURAL LIGHT. (See Page 57.)

The superiority, from the lighting standpoint, of one story buildings, has already been mentioned; this allows over-head illumination, which is effective in distributing the light evenly over the central portion of rooms where the light from side windows is necessarily much weaker than it is close to the building walls. By the use of saw-tooth or monitor roofs, or by sky-lights of heavy ribbed glass, the direct light of the sky may be distributed with practical uniformity over the entire floor area.

Where buildings are more than one story in height and the light must be admitted entirely through windows in the walls, the problem is much more difficult to handle; an effort should be made, however, to secure the following conditions: —

(a) **Adequate window area** in proportion to floor area; Mr. D. R. Wilson in a special report on illumination in factories (see Annual Report English Factories and Workshops, year 1911) recommends that the window area be at least 10% of the floor area served, 20% to 30% being generally desirable.

(b) **Maximum Height of Windows.** Direct light from the sky is much stronger than that reflected from the ground or buildings, so it is important to have high rooms and carry the windows up as near to the ceiling as practicable. A few inches added to the height of the windows may make a great improvement in the illumination, particularly in the centre of the room where the light is poorest.

(c) **Avoidance of Obstructions.** So far as possible windows should be located so that the illumination through them will not be reduced or cut off by adjacent buildings.

(d) **Proper Arrangement of Machinery.** The

Fig. 1. Plant of Gray & Davis, Boston, exterior view. The walls have been practically all utilized for window space. The area of windows is about 43% of the entire floor area.

Fig. 2. Gray & Davis Plant, interior. The arrangement of this building is such as to give excellent illumination, the interior finish diffusing the light throughout the room. To the eye, the central bays appear practically as light as those at the sides.

Fig. 3. United Shoe Machinery Plant, Beverly, Mass. These buildings may be taken as models of factory construction. They are of fire-resisting material, moderate height, and have liberal light-courts, with a window area of approximately 30% of the floor area.

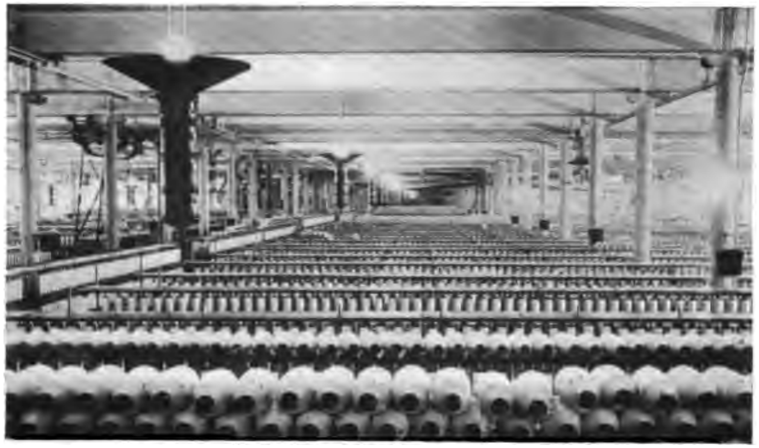


Fig. 4. Cotton Mill, with Indirect Lighting. Practical uniformity of illumination is also secured in this case.

machinery should be so arranged in relation to the windows that it will not obstruct the light unduly. The best method is to have the machines placed in rows which run at right angles to the wall containing the windows. The value of this arrangement is commonly overlooked, and in many plants, machines, tables, etc., are placed in lines parallel with the sides of the wall, and so arranged that the operators are either in their own light or troubled by glare from the windows which they face. (See item "c" of Prof. Webber's table.)

ARTIFICIAL LIGHT (See Page 59.)

Ideal conditions can usually be more nearly secured in connection with artificial lighting than with natural light, because the intensity and location of the former can be more readily controlled. In the arrangement of artificial lights the following points are important: —

(*a*) **Size of Light Units**. In order to properly diffuse the light, small units spaced at frequent intervals are desirable, particularly in low rooms where the lights come within the ordinary angle of vision.

Where the ceilings are high and the lights can be placed well above the line of vision, larger units with wider spacing may be used, as there is less trouble from glare and the light will be more evenly distributed over the floor area.

(*b*) **Location of Light Units**. Lights, unless suitably shaded, should be placed at such a height as will keep them well outside the normal line of vision. (A minimum angle of 30° has already been mentioned.) The lights should be located to the side of the working positions so as to avoid undesirable shadows.

Where ceilings are low, or where a concentrated light is needed for the work, the eyes should be protected from glare by providing a suitable shade for each lamp. (Fig. 5, P. 301.) Such shades should be either opaque, or of such translucency as will reduce the resulting intrinsic brilliancy to the limit already mentioned in the discussion of "Glare."

During the past few years there has been rapid progress in perfecting various types of lighting equipment, so there is now a considerable range from which to choose. No attempt will be made to describe these various types other than to point out some of their general characteristics.

Electricity is to be preferred to gas or oil for industrial lighting, for several reasons.

(*a*) It does not vitiate the air.

(*b*) The danger of fire or explosion is considerably less.

(*c*) It is possible to secure lighting units of practically any size, intensity, or quality desired.

(*d*) It can be handled with more facility in arranging the lights, or in altering their location to suit special conditions.

Where color is an important factor, as in the inspection of colored fabrics or papers, the light should be "white" or as nearly as possible like sunlight. This quality is most nearly approximated at the present time (1915) by the Tungsten-filament gas-filled lamp. Where color is not a factor, lamps of the Mercury Vapor, or "Flaming Arc" type give excellent results, and they do not cause the same discomfort as white light for a given degree of illumination, on account of the fact that their light is very low in actinic rays.

INTENSITY OF ILLUMINATION

The intensity of illumination needed for different operations is an exceedingly variable quantity, for which it is difficult to outline definite standards. It is governed by the nature and degree of fineness of the work to be done, by the quality of the surface worked upon (whether light or dark in color, rough or polished, etc.), and, to a certain extent, by the visual requirements of each individual.

The following list, which is based upon data published by the National Electric Light Association, indicates the approximate amount of illumination considered desirable in certain characteristic industries. It is stated in terms of foot-candles on a horizontal surface thirty to thirty-six inches above the floor.


Fig. 1. Artificial Lighting in Drafting-room.


Fig. 2. Artificial Lighting in Carpenter Shop.



Fig. 3. Cut-out Hanger. Fig. 4.

Figs. 1 and 2 show an excellent provision of artificial light. The illumination is uniform throughout. The lamps are of such height and arrangement as to avoid eye-strain and any unpleasant sense of " glare."

Figs. 3 and 4 show safety cut-out hanger for arc lamps. The use of this hanger is very advantageous from the safety standpoint. It does away with the necessity of climbing over-head to trim lamps, and completely disconnects the lamp from the circuit, thus making certain it is dead before being touched by the trimmer or repair-man. The hanger gives an extra support, in addition to the ordinary cord, thus practically eliminating any danger of the lamp breaking away from its supports and falling on persons below.


Fig. 5. Lock for Incandescent Lamp.

Fig. 5 shows an arrangement for locking incandescent lamps in sockets; some such device can often be used to advantage for maintaining lights in stairways and other places where the bulbs are likely to be stolen.


Fig. 6. Guards for Reflectors.

Fig. 6 shows wire guards to prevent injury to persons below in case the heavy glass reflectors should break or become detached.

1 to 3 foot-candles. Ordinary packing and shipping, stock-rooms, cotton mills (opening, carding, drawing, roving, etc.), bakeries, general blacksmith-shop work, foundries, meat packing, etc., etc.; this degree of illumination is satisfactory for general lighting in factories, where there is no especially fine work. Where the latter is found, local illumination of greater intensity is usually required. (See Fig. 5, P. 301.)

2 to 5 foot-candles. Book-binding, candy making, cotton weaving, dairies, ordinary machine work, wrapping and packing, (fine) pottery-works, printing establishments (proof reading, paper cutting and folding, etc.).

4 to 6 foot-candles. Embossing, leather-cutting, pressing, etc., shirt manufacturing, machine work (assembling, erecting, inspecting, etc.), offices (general lighting), painting (ordinary,— wagons, signs, etc.), punching, pressing, stamping, etc., shoe manufacture (misc. machine and bench work, hand sewing, etc.), wire-drawing, etc., etc.

5 to 10 foot-candles. Clothing manufacture (hand sewing, inspection, etc.), weaving (inspection), drafting, lithographic-engraving, fine machine work (bench and lathe, etc.), painting (paint-mixing and matching, design and figure work, automobile, carriage and fine cabinet work, etc.), linotype and monotype, typesetting, shoe cutting, inspecting, machine stitching, etc.

10 to 15 foot-candles. Fine sewing machine work, steel engraving, etc.

15 to 40 foot-candles. Dyeing (inspection).

(For further details, and suggestions as to the arrangement of lights for particular industries and machinery, see "Industrial Lighting," published by the National Electric Light Association.)

CHAPTER 9

VENTILATION

WHILE it is impossible to demonstrate accurately the relationship between ventilation and accidents, there can be no doubt that such a relation does exist. Inadequate ventilation tends to reduce the alertness of the workmen and bring on fatigue; persons suffering from fatigue are surely more liable to accidents than those who are not. This is shown, in a measure, by the fact that the accident frequency when tabulated by hours, usually increases towards the end of the turn. (See "Fatigue," Thos. F. Darlington, Safety Engineering, Oct., 1913.)

In many industries, all that is needed to secure proper ventilation is to introduce sufficient quantities of fresh air to renew that which has become vitiated. Incidentally this may be combined with heating, cooling, or washing processes, so as to maintain the right degree of temperature and humidity.

Where dust or noxious vapors are encountered it is necessary to provide for their removal by the installation of a suitable exhaust system. The problem here becomes one of more than mere ventilation. The lack of proper facilities for removing such dust or vapors may result in the contraction of trade diseases.

The subject of ventilation has been discussed in a paper by Walter B. Snow, entitled "Mechanical Ventilation and Heating By Forced Circulation of Warm Air"; this, and another treatise entitled "Heating and Ventilation," are published by the B. F. Sturtevant Company, by whose courtesy the following paragraphs are reprinted: —

"**Although carbon-dioxide or carbonic-acid gas** is the principal product of respiration, it is by no means the most harmful. The true evil of a vitiated atmosphere lies in its other constituent gases and micro-organisms, which, however, are difficult of determination. Fortunately they preserve a fairly constant proportion to the amount of carbonic acid present. As this gas is readily determinable, its relative amount in a given volume of air is generally accepted as a measure of its purity.

Assuming four parts of carbonic acid in 10,000 parts of air as the normal vitiation of the external atmosphere, and 6-10 of a cubic foot per hour as the amount of carbonic acid exhaled by an average person, we have the accompanying requirements regarding the air supply necessary to maintain a given standard of purity within an apartment.

Cu. ft. of air, per person *Per Hour*	Degree of vitiation of air in room *Parts of carbonic acid in 10,000*
6000	5
4000	5.5
3000	6
2400	6.5
2000	7
1800	7.33
1714	7.5
1500	8
1200	9
1000	10
545	15
375	20
231	30

A supply of 30 cubic feet per person per minute, by which, under these conditions, the degree of vitiation is maintained at 7.33 parts carbonic acid in 10,000 of air, has been very generally accepted as the minimum volume permissible for the requirements of what may be considered good ventilation. This marks the practical limit of the most successful systems where mechanical means are *not* employed. In point of fact the average for such systems is well below this amount.

The design and manner of application of heating and ventilating apparatus, and the method of air distribution employed, must of necessity depend upon the character of the building, its surroundings, and its uses. The ordinary structure devoted to manufacturing purposes presents the simplest of all problems. As a rule the per-capita space for the operatives is large, and the heating is to be considered as of paramount importance, while the ventilation, although sufficient with the blower system, is in a sense incidental. In fact, ample ventilation may usually be secured by allowing the fan to draw its supply from the building itself, thereby simply turning the air over and over, and merely adding to it the heat necessary to offset the transmission and leakage losses. To this end it is most desirable that the apparatus be placed as near the centre of the building as possible, so that the air may be drawn back to it from all sides. Such location also simplifies the distributing system and reduces the cost.

From the apparatus the air may be conducted by underground ducts or overhead pipes to its proper destination. Inasmuch as the best results are secured by discharging the heated air above head level in a horizontal or slightly downward direction and towards the outer walls, it is usually most convenient in a one-story factory building to carry the piping overhead in the manner shown in Fig. 6, P. 63.

In this case the apparatus is supported upon a platform in one corner of the building, because of the proximity of the exhaust-steam supply. The hot-air piping is placed overhead, and carried entirely around the interior. Air as a rule is returned from the building, but the large window area with consequent leakage is sufficient to bring about a constant air change to meet all purposes of ventilation.

If the fan in such a building is of the steel plate type, it is usually operated at a maximum speed corresponding to a circumferential velocity of the wheel of about a mile a minute. If the fan is of the multiblade type, the circumferential velocity will be about 4200′ per minute. The velocity of discharge through the outlet of the steel plate fan would be approximately 3200′ per minute and through the outlet of the multiblade fan 4500′ per minute, if there were no restriction due to the heater and piping. These velocities, however, will be decreased in proportion to the resistance of the system. In ordinary factory work these velocities will be approximately 2400′ per minute for fans of the steel plate type and 3500′ per minute for fans of the multiblade type. Although low velocities are evidently conducive to an economical movement of air, the objection to large ducts necessarily limits their size, while the customary utilization of the exhaust steam from the fan engine reduces the possible saving to a very small amount.

For factory heating, the main discharge pipe leading from the fan is generally of the same area as the outlet with fans of the steel plate type, and 45% greater with fans of the multiblade type. The resistance of branches is compensated for by increasing area so that the aggregate area of the outlets will range from 35% to 60% in excess of the main discharge pipe, and the corresponding discharge velocities will be decreased to 1800′ or 1500′ per minute, or even lower when the resistances are great.

It is frequently possible in a building of the character just presented, to secure satisfactory circulation of the air with a limited extent of ducts by discharging the air at high velocity, and thus compelling it to continue its direction of movement for a considerable distance without the use of conducting pipes. The possible simplicity of this construction is largely due to the character of the work carried on within the building, especial refinement in the manner of distribution being unnecessary where the operatives are actively employed.

There are other cases, however, where, owing to the presence of obstructions within the building, the air can be forced only a short distance from the pipe outlet, and local distribution is necessary.

In the familiar gallery type of manufacturing building the problem of air distribution becomes somewhat more complicated because of the impossibility of carrying pipes across the central space through which the crane travels, or of successfully forcing the air across this space. It therefore becomes necessary to provide for distribution upon both sides. Either of two methods may be employed. In the former the apparatus discharges the air through underground ducts to galvanized-iron flues, placed against the walls on both sides of the building. From these the air is delivered along the walls above head level.

In the second arrangement, illustrated in Fig. 1, P. 63, two independent apparatuses are employed. They are placed in the galleries midway of the length of the building, and each delivers the air to a double system of pipes, one for each floor, whence it is discharged toward the outer walls. This is an ideal arrangement for the return and reheating of the air.

In buildings of more than one story, the simplest arrangement for heating consists in placing the apparatus on the lower floor or in the basement, and delivering the air into one or more vertical flues from which it is discharged through suitable outlets upon the several floors. In a wooden structure, or in one of brick or stone which is already built, such distribution must be made by means of galvanized-iron pipes.

The simplest possible arrangement consists of a single upright galvanized-iron flue, immediately beneath which the apparatus is placed so as to

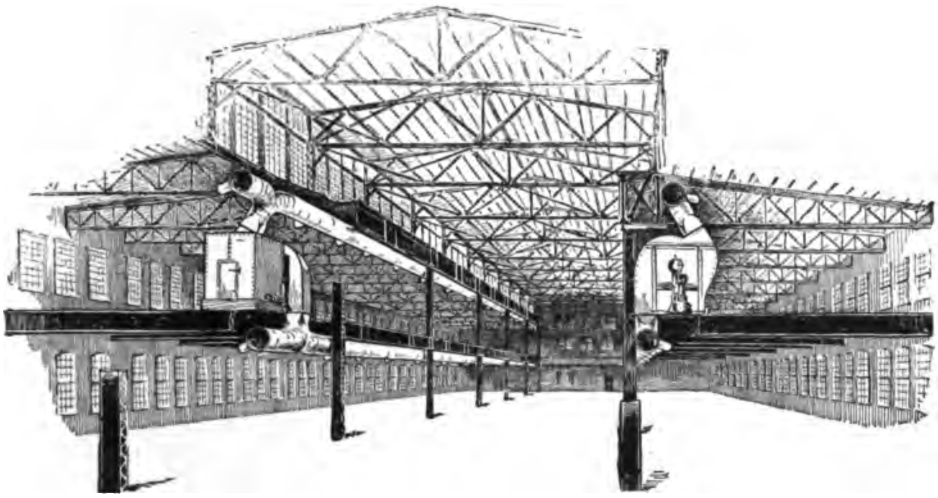


Fig. 1. Gallery Type Building, — Two Independent Fans.

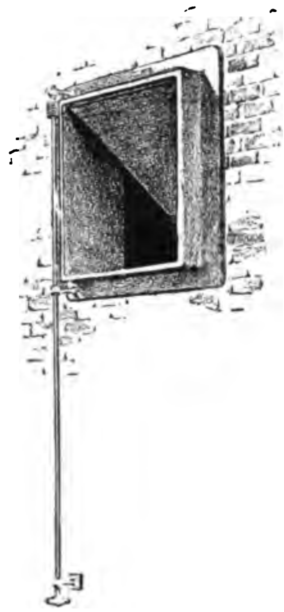


Fig. 2. Wall Damper.

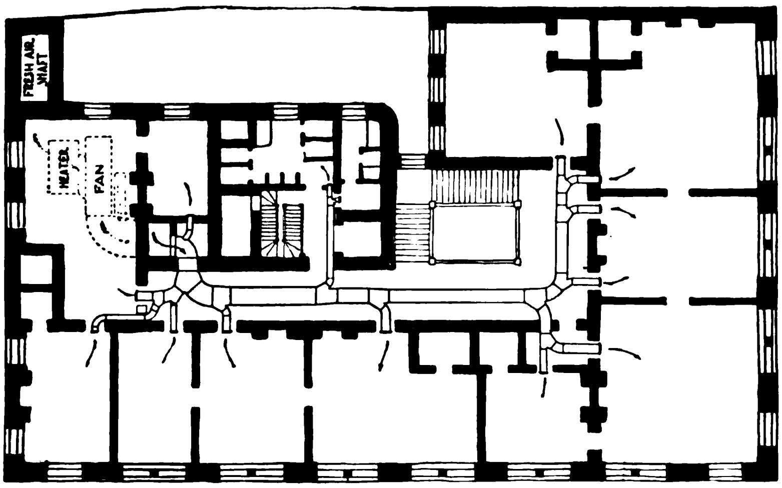


Fig. 3. Office Building Ventilating Arrangement.

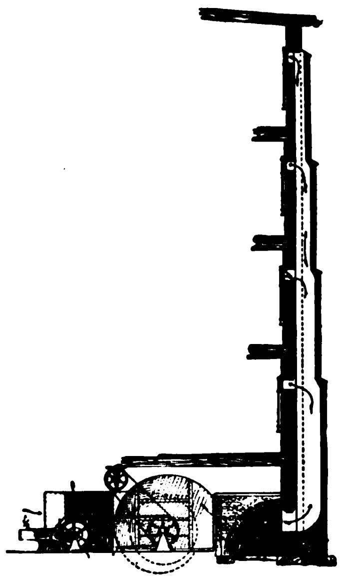


Fig. 4. Pilaster Flue.

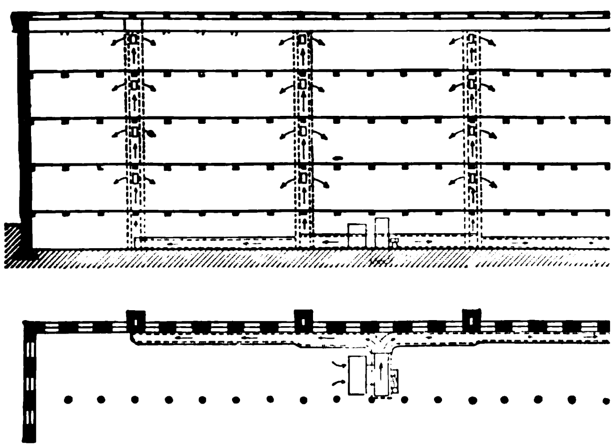


Fig. 5. Pilaster Flues in Side Wall of Building.

Fig. 6. One-story Building, — Single Fan.

deliver the air directly upward into the base of the flue. Upon each floor the requisite number of outlets are provided at or near ceiling level and the air discharged therefrom towards the outer walls.

In a new brick building, convenience can be secured by distributing the air from one or more brick flues built against the wall of the building. If these are provided in sufficient number they require no distributing pipe connections, but if economy is sought by providing a single flue, then it becomes necessary to obtain satisfactory distribution on each floor in some such manner as an individual system provided at the ceiling of each floor. Where the building is of less extent, a special deflecting outlet may be placed upon the opening in the flue on each floor and serve to effectually distribute the air.

In a new brick structure of reasonable size, the best arrangement consists in building a series of pilaster flues against the outer wall along one side of the building, from each of which the air is discharged toward the opposite side through openings at eight or more feet above the floor. The modern textile mill with its symmetrical design is manifestly adapted for such an arrangement.

The apparatus is usually placed in the basement, near the centre of the building, and discharges the air into a duct running along one side of the building, and communicating with the bases of the flues, as illustrated in Figs. 4 and 5, P. 63.

These flues add but little to the cost of the building. Each opening or outlet is provided with a special form of damper, Fig. 2, P. 63, which serves the double purpose of deflecting the air toward the room when open, and of preventing admission when closed.

The large amount of moving machinery, pulleys, shafting and belts in such a building serves to thoroughly break up all air currents and effectually distribute the air.

In an office building of several stories an arrangement like that shown in Fig. 3, P. 63, serves for thorough distribution, the apparatus being placed in the basement and discharging the air into a vertical flue with connections to horizontal ducts on each floor. These ducts are arranged on the corridor system, the admission to each room being made at or near the ceiling.

Ordinary practice in school-house heating and ventilation limits the fan speed to that required to produce about one-half ounce, or $\frac{7}{8}$ in. pressure per square inch, equivalent to a tip velocity of the wheel of about 3,600 ft. per minute. Duct velocities will then range from 1,200 or 1,500 up to 2,000 ft. per minute, flue velocities from 500 to 800 ft., and velocities of discharge to rooms from 300 to 400 ft.

Under good school-room conditions, with a space allowance of 250 cubic feet per occupant, a supply of 50 cubic feet per minute, or 3,000 cubic feet per hour per individual, appears to mark the practical limit of success for imperceptible admission of air. This is equivalent to changing the entire volume within the room once in five minutes. Increased volumes call for increased care in the manner of introduction, as evidenced in lower velocities and the greater extent of inlet openings."

Air Washing and Humidifying may be accomplished at the same time, and by the same apparatus. This apparatus consists of a chamber containing spray nozzles or washers, through which the air passes before it is admitted to the building which is being ventilated. The washing process is of value in that it eliminates dust or dirt which is generally present in the air, particularly in cities and around manufacturing plants.

By maintaining suitable temperatures in the air heating and washing apparatus, the humidity may be regulated to suit varying atmospheric conditions. In summer, when the humidity is relatively great, the water in the washer is kept at a temperature considerably below that of the atmosphere; the warm outside air entering the washer is chilled below the "dew point," so that the excess moisture is condensed and thus removed.

In winter the process is reversed; the cool outside air, which is relatively dry, is heated before it enters the washer; this raises the temperature but lowers the relative humidity. Moisture is then absorbed as the air passes through the washer, after which it is again heated and enters the room, containing sufficient moisture for the requirements of health.

The removal of dust, acid fumes, and noxious or explosive vapors of various kinds is a more difficult problem. Conditions are exceedingly variable, but it is usually necessary to provide artificial draught by means of a mechanically operated exhaust system. The intakes of this system should be placed as close as possible to the source of the dust or fumes,

Fig. 1. Nickel Plating Dept., Eastman Kodak Company. Note arrangement of exhaust system for carrying off acid fumes and steam, also method of covering tanks.

Fig. 2. Dipping Room, General Electric Company. The exhaust openings immediately above the tanks collect the steam and fumes before they have opportunity to spread.

Fig. 3. Buffing Dept., Eastman Kodak Company. This department has an excellent exhaust system, as will be noted by the photograph.

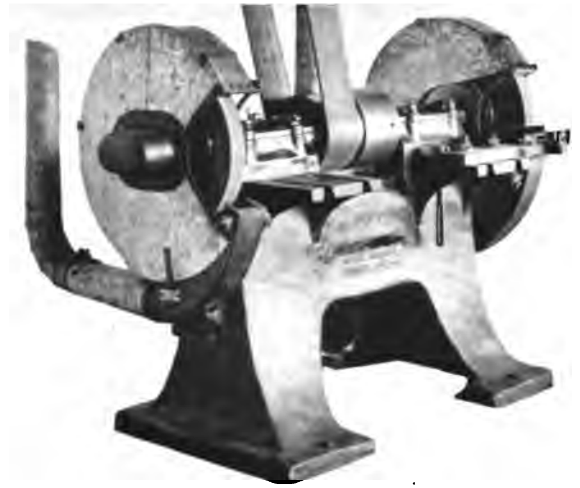


Fig. 4. Protected Emery Wheel, United Shoe Machinery Company. Note the safety hood and dust collector, also cap over end of spindle.

so as to prevent the latter from becoming diffused. The discharge of harmful or dangerous fumes or vapors should be at a point where it will do no injury. (See Pages 65 and 67.)

Exhaust Systems for Grinding, Polishing, and Buffing Wheels

The following detailed information on exhaust systems for grinding wheels, etc., is taken from data prepared by Mr. William Newell, M.E., for the New York State Department of Labor, and issued by it in bulletin form.

Minimum sizes of branch pipes to be as follows: —

FOR GRINDING WHEELS

Diameter of Wheels	Maximum grinding surface	Minimum diameter branch pipe
6″ or less, not over 1″ thick	19 sq. in.	3″
7″ to 9″ inclusive, not over 1½″ thick	43 " "	3½″
10″ to 16″ inclusive, not over 2″ thick	101 " "	4″
17″ to 19″ inclusive, not over 3″ thick	180 " "	4½″
20″ to 24″ inclusive, not over 4″ thick	302 " "	5″
25″ to 30″ inclusive, not over 5″ thick	472 " "	6″

In case a wheel is thicker than given in the above tabulation, or if a disc instead of a regular wheel is used, it must have a branch pipe no smaller than is called for by its grinding surface, as given above.

FOR BUFFING OR POLISHING WHEELS

Diameter of Wheels	Maximum grinding surface	Minimum diameter branch pipe
6″ or less, not over 1″ thick	19 sq. in.	3½″
7″ to 12″ inclusive, not over 1½″ thick	57 " "	4″
13″ to 16″ inclusive, not over 2″ thick	101 " "	4½″
17″ to 20″ inclusive, not over 3″ thick	189 " "	5″
21″ to 24″ inclusive, not over 4″ thick	302 " "	5½″
25″ to 30″ inclusive, not over 5″ thick	472 " "	6½″

Buffing wheels 6″ or less in diameter used for jewelry work may have a 3″ branch pipe.

All branch pipes must enter the main suction duct at an angle not exceeding forty-five degrees (45°) and must incline in the direction of the air flow at junction with main.

The inlet and outlet of the fan or exhauster shall be at least twenty per cent (20%) greater in area than the sum of the areas of all the branch pipes. This increase shall be carried proportionately throughout the entire length of the main suction duct, i.e., the area of the main at any point shall be at least twenty per cent (20%) greater than the combined areas of the branch pipes entering it between such point and the tail end or dead end of the system.

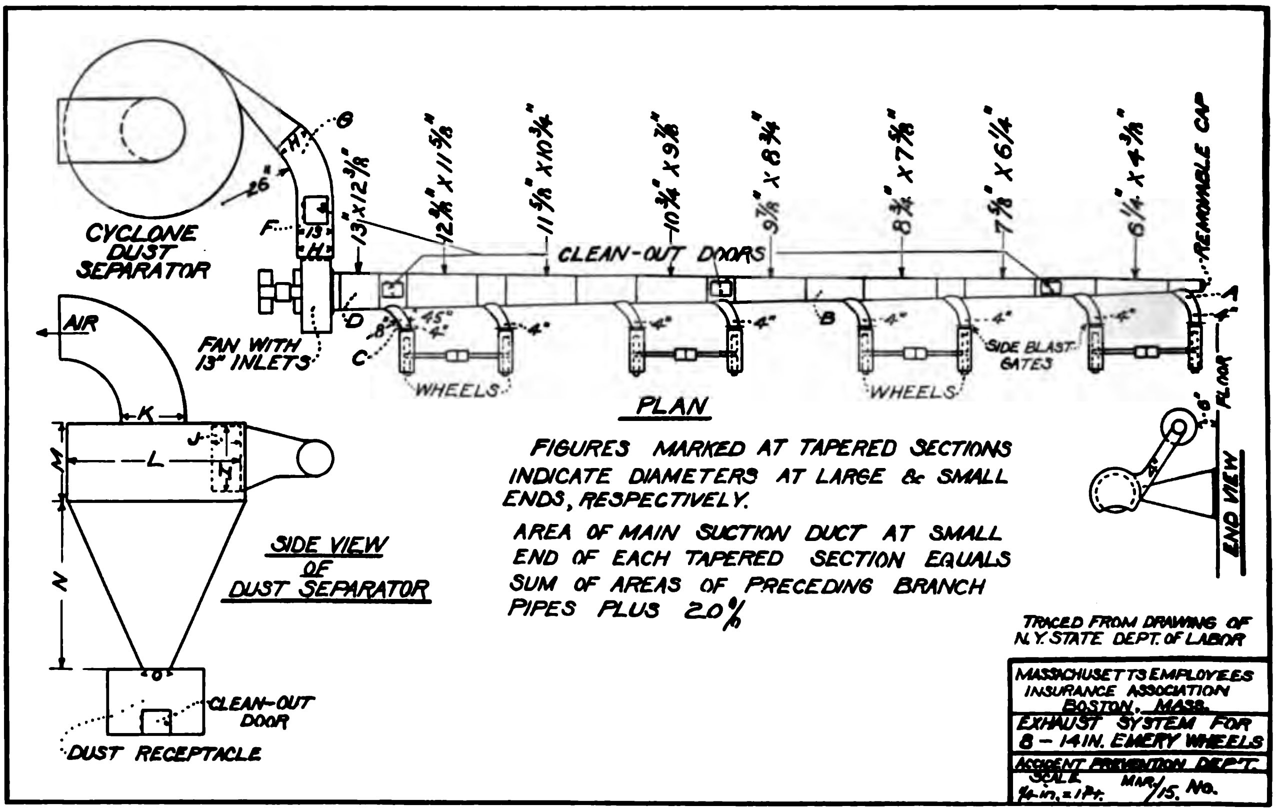


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1 shows ventilating pipes over a wire drawing frame in one of the plants of the American Steel and Wire Company.

Fig. 2 is a photograph of a ventilating hood over an oil furnace in a brass foundry of the General Electric Company.

Fig. 3 shows mixers, scales, and rolls provided with exhaust hoods, — also in one of the General Electric Company plants. Note cyclone separator in the corner of the room, into which the various pipes discharge.

Fig. 4.

Fig. 5.

Fig. 4 shows a surface grinder and Fig. 5 a double disc sander, in plants of the Eastman Kodak Company, both of which are provided with hoods and exhaust connections.

The main trunk lines, both suction and discharge, shall be provided with suitable clean-out doors not over ten (10) feet apart, and the end of the main suction duct shall be blanked off with a removable cap placed on the end.

Sufficient static suction head shall be maintained in each branch pipe, within one foot of the hood, to produce a difference of level of two inches of water between the two sides of a U-shaped tube.

Emery wheel and buffing wheel exhaust systems should be kept separate owing to danger of sparks from the former setting fire to the lint dust from the latter, if both are drawn into the same suction main.

Both the main suction and discharge pipes should be made as short and with as few bends as possible, to avoid loss by friction. If one or the other must be of considerable length, it is best to place the fan not far beyond where the nearest branch enters the large end of the main, as a long discharge main is a lesser evil than a long suction main.

Avoid any pockets or low places in ducts where dust might accumulate.

The main suction duct should be enlarged between every branch pipe entering it, whenever space permits, and in no case should the main duct receive more than two branches in a section of uniform area. All enlargements in the size of the main should be made on a taper and not by an abrupt change.

Branch pipes should enter the main on the top or sides — never at the bottom. Two branches should never enter a main directly opposite one another.

Each branch pipe should be equipped with a shut-off damper, or blast-gate, which may be closed, if desirable, when the wheel is not in use. Not more than 25% of such blast gates should be closed at one time; otherwise, the air velocity in the main duct may drop too low and let the dust accumulate on the bottom. Dampers should be of the sliding type; not the stove-pipe or butterfly type.

Branch pipes should lead out of the wheel hood as nearly as possible at the point where the dust will naturally be thrown into them by the wheels. This is very important.

All bends, turns, or elbows, whether in main or branch pipes, should be made with a radius in the throat of twice the diameter of the pipe on which they are connected, wherever space permits.

Elbows should be made of metal one or two gauges heavier than the pipe on which they are connected as the wear on them is much greater.

CHAPTER 10

STAIRWAYS, RAILINGS, AND OTHER BUILDING FEATURES

ACCESSIBILITY

In designing a building, too little consideration is frequently given to the importance of having all apparatus requiring periodical attention, such as windows, lights, cranes, overhead operating valves, tanks, etc., readily accessible.

The cleaning of windows in a large Pennsylvania plant was attended with unusual hazard, on account of the arrangement of the buildings. A window-cleaner fell and was fatally injured, as a result of which, orders were given that the windows should not be cleaned again, until a safe method had been provided for doing this work. Window cleaning facilities, consisting of travelling trolleys located in the building trusses, were later installed at a cost of several thousand dollars.

If provisions of this sort are included at the time a building is constructed, they can be secured at the lowest possible cost, and can be arranged so as to give the highest degree of convenience and utility.

Wherever necessary, suitable runways or platforms should be erected, from which all such elevated equipment can be reached. Safe and convenient means of egress should be provided for such platforms. For this purpose, stairways are preferable to ladders of any type, and fixed ladders are less hazardous than portable ones. (See also "Ladders," Chapter 24.)

STAIRWAYS — CONSTRUCTION AND ARRANGEMENT, ETC.

(1) Stairways are a prolific cause of injury. Out of approximately 90,000 accidents reported in one State during one year, from all causes, 860, or approximately one per cent of the total, came from falls down stairs. In addition to minor accidents, these falls caused fractures and other serious injuries in many cases, and death in one case.

Steep stairways should be avoided. For the best safety conditions, the angle from the horizontal should be somewhat less than 45° (say 30° to 35°). The combined riser and tread should be about $17\frac{1}{2}''$, a good combination being 6″ to 7″ risers and $10\frac{1}{2}''$ to $11\frac{1}{2}''$ treads. If insufficient room necessitates steep stairways, ladders should be substituted when the angle from the horizontal is 50° or over.

Handrails should be provided for stairways as follows: —

(1) On open side or sides of unenclosed stairways. (See Fig. 3, P. 74.)
(2) On one side of enclosed stairways less than 3′ in width. (See Figs. 4 and 5, P. 70.)
(3) On both sides of enclosed stairways 3′ or more in width. (See Fig. 2, P. 70.)
(4) On both sides and in centre of stairways over 7′ in width.* (See Fig. 1, P. 70.)

Handrails should be of substantial and rigid construction, firmly secured, smooth and free from protruding nails, bolts, splinters, etc. They should preferably be located 36″ to 42″ in height vertically from centre of tread. The latter height is particularly desirable for open stairways, in order to avoid danger of persons falling over the railing. For open stairways there should be an intermediate member between the upper rail and the treads. For enclosed stairways the handrail may be secured to the wall, from which it should project about 3″.

Circular stairways should be avoided in new construction. The varying width of tread at different points is confusing and liable to cause falls. Dizziness may result in passing down a circular stairway of any considerable height. Where circular stairs have been installed they

* A good arrangement for wide stairways which are used by many people is to divide the stairway into sections, 22″ to 24″ in width, by railings. This makes certain that any one stumbling on the stairway will be able to reach a railing.

Fig. 1. Wide Stairway with Intermediate Handrail.*

Fig. 3. Emergency Light for Stairway. (Eastman Kodak Company.)

Fig. 2. Safety Features for Stairway.*

Fig. 2 shows an excellent safety installation. The stairs are equipped with good railings and with safety treads. An overhead electric lamp is provided, and the walls are white, diffusing the light.

Fig. 3 shows an emergency lighting arrangement for stairway. If the regular current supply should fail, pushing button on outside of switch-box would throw on current from another source, and thus permit the employees to see their way out. This device is located just outside the fire door which gives access to the stairway.

Fig. 4. Hinged Stairway Enclosure, lowered.

Fig. 5. Hinged Stairway Enclosure, raised.

Figs. 4 and 5 show an ingenious arrangement for providing a fire enclosure and handrail for a stairway which must be used occasionally for handling objects wider than the stairway.

* Courtesy of the Boston Elevated Railway Company.

should have a handrail at the inner side so located as to cut off and prevent the use of that portion of the tread which is less than 7″ in width.

Stairways should be well lighted at all times during working hours. (See Figs. 2 and 3, P. 70.) This usually requires artificial light during certain parts of the day, even where the natural light is good. The New York Compensation Inspection Rating Board has set the following standard of stairway lighting: —

"A poorly lighted flight of stairs is one in which 10-point type cannot be read at a distance of 18″, without eye-strain, by a person of normal vision, facing in any direction, at any time during working hours."

Stair treads should be of such material and construction as will prevent their wearing smooth and becoming slippery. Where service conditions are severe, iron or steel plates with "checkered" or roughened surfaces may be used advantageously. A good non-slipping tread with long life under severe service conditions consists of plates surfaced with an abrasive material, such as carborundum or alundum. (See Page 72.)

Where concrete construction is employed, abrasive crystals about the size of buckwheat may be embedded in the surface of the concrete while it is still soft, giving a similar but somewhat less effective form of "safety tread."

Where service conditions are moderate, a composition tread (rubber, cork, etc.) may be satisfactorily used. This furnishes a non-slipping surface, but is not so permanent as the materials first mentioned.

Any irregularity in the height or width of stair treads is liable to cause falls. Treads should be repaired or replaced when the surface or nosing shows wear to the extent of $\frac{3}{8}$″ or more. The treads should be rigidly fastened in place, without any noticeable unevenness or projections above the surface.

From the safety standpoint, grooves in treads are undesirable. If grooved treads are used, the grooves should be shallow and should not extend nearer to the nosing or edge of the tread than 3″; otherwise they are liable to catch the heels of persons using the stairway. The grooves also cause confusion by making it difficult to distinguish the edge of the treads when descending the stairway.

Landings should be provided at intervals in long runs of stairs. The Boston Building Code calls for landings in all flights of more than fifteen steps, but requires at least three steps between such landings.

In planning a building, the arrangement should be such as to avoid unexpected entrance upon flights of steps. It is undesirable to have stairs start immediately at a doorway, without a landing. Persons passing through the doorway may be taken unawares and precipitated down the stairway.

Where a swinging door is located at the top of a flight of steps and swings towards the steps, and the arrangement cannot be changed readily, a glass panel (preferably of wired glass) should be placed in the door, as specified later for "double-swinging doors."

Where there is any fire hazard, stairways should be enclosed so as to cut off the progress of smoke or flames, as mentioned in Chapter 6. (See Fig. 4, P. 70.) The treads and risers and their supports should be constructed either of incombustible materials (Fig. 3, P. 72), or of heavy wood, so as to offer the maximum resistance to fire.

RAILINGS AND TOE-BOARDS

All elevated platforms, balconies and runways 4′ or more in height, also stairway landings, openings through floors, etc., should be protected by railings or barriers at exposed edges; platforms, etc., 6′ or more in height, should have a toe-board at base of railing. For such railings the following standards are recommended: —

"Standard" railings to be of substantial and rigid construction, firmly secured, smooth, and free from protruding nails, bolts, splinters, sharp edges, etc. Railings should consist of a top rail, intermediate rail and toe-board or coaming. (See Fig. 2, P. 74.)

Height of top rail, — 3′ 6″
Height of toe-board, — 6″

Fig. 1. Railing, etc., at Stairway.*

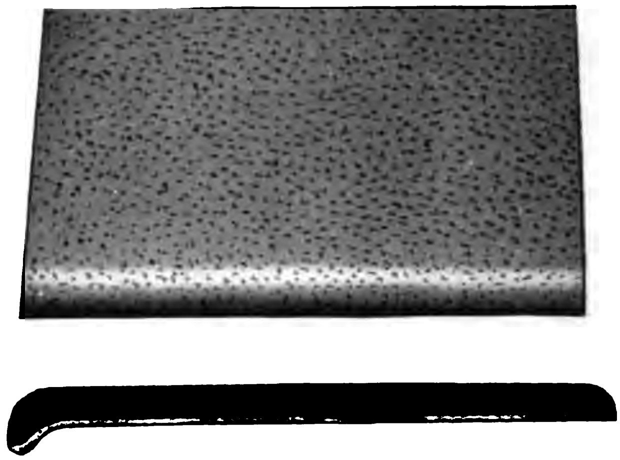


Fig. 4. Type of Safety Tread.

Fig. 2. Method of Repairing Worn Tread.

Fig. 5. Safety Tread in Floor of Boiler House.

Fig. 3. Type of Safety Tread.

Fig. 1 illustrates a stairway safeguard consisting of a screen to prevent danger of persons falling over the railing. This screen extends to the floor line, thus serving as a toe-board along the exposed edges of the landings and steps.

Figs. 2, 3, and 4 show types of "safety tread," consisting in each case of an abrasive material such as carborundum, embedded in metal. This gives good wearing qualities with a "non-slipping" surface.

Fig. 3 illustrates a simple and effective method for repairing a worn stairway, by the use of "safety tread" material.

This material can also be used to advantage at elevator entrances and on steps about engines, printing presses and other machinery; also in floors, or in any location where there is danger of slipping.

Fig. 5 shows safety tread material at the firing position in front of boilers. (Note also safety catch on lower door-latch, to prevent furnace doors from being blown open.)

* Courtesy of Eastman Kodak Company.

Railings 3′ or less in height are frequently used, but they are below the centre of gravity of an average man and there is danger of persons falling over them.

Toe-boards are intended to prevent feet from slipping under the railing, or loose objects such as tools or spare parts, from falling off and injuring persons below.

A 6″ toe-board is ordinarily adequate but in some cases it may be desirable to enclose the space between the platform and the middle rail with sheeting, woven wire fabric, etc. This practice is advantageous where brick or other materials are liable to be piled to such a height along side the railing that they might fall over an ordinary coaming. It is also desirable around blast furnaces, gas plants, etc., where persons might be overcome by gas and roll underneath the railing.

The following materials are recommended for the construction of railings: —

Structural steel railings: — angles not less than 2″ x 2″ x ¼″ for top rails and posts; bars not less than 2″ x ¼″ for intermediate rails; flats not less than 3/32″ by 6″ for toe-boards.

Pipe railings: — extra heavy 1¼″ pipe throughout, with malleable iron fittings and wide flanges; toe-boards same as above.

Wood railings: — not less than 2″ x 4″ for top rails and 1″ x 6″ for intermediate rails and toe-boards; posts not less than 4″ x 4″ cross-section.

The following spacing is recommended for posts: —

Metal,— not more than 12′, preferably 10′.
Wood,— not more than 8′.

Corners of posts should be chamfered.

The above sizes are recommended as minimum standards. Where service conditions are unusually severe, the sizes should be increased.

Metal railings are preferable to wood (unless exposed to acid fumes or other unusual conditions) on account of their greater permanence and stability. Riveted structural steel railings are superior to pipe railings for service where there is vibration which might cause a pipe railing to work loose. (For example, use on footwalks of electric traveling cranes.) Where fixed railings are impracticable, portable railings should be maintained. (See Page 74.)

FLOOR OPENINGS

In general, openings through floors, platforms, etc., should be avoided. Where large openings of this kind necessarily occur, they should be provided with permanent standard railings; where these are impracticable, portable or removable railings may be substituted. Small openings should be protected by means of suitable covers, which should be hinged or otherwise permanently attached, to prevent their complete removal. It is often possible to equip such covers with rest-rods, which support the cover at such an angle as will permit easy access from the open end, but still form a barrier at the three unused sides. (See Fig. 3, P. 379; see also Chapter 6)

DOORS AND DOORWAYS

Door openings in outside walls are occasionally provided for giving access to "yard arms," block and tackle, etc. All such doorways from which there is a clear drop of 4′ or more should be protected. (See Fig. 1, P. 19.) For this purpose the following standards are recommended: —

Permanent railings not less than 3′ 6″ in height, with an intermediate rail, should be installed where practicable. If there is a clear drop of 6′ or more from such doorways and persons work or are liable to pass underneath the doorway, a standard toe-board should be provided at base of railing.

Where permanent railings of this sort are impracticable, a self-closing door or gate of solid or grill-work construction, not less than 3′ 6″ in height and extending to floor line should be installed.

Such doors or gates are recommended in addition to the ordinary door, wherever the latter is left open at intervals for ventilation or other purposes. The auxiliary door or gate should be kept closed at all times, except when in actual use.

Double-swinging doors should have glass panels, so arranged as to permit persons approaching on one side of a door to see through it, and avoid danger of collision with any one

Fig. 1. Removable Railing at Loading Platform.*

Fig. 2. Standard Railing and Toe-board for Overhead Platform.†

Fixed railings are preferred on account of the difficulty of keeping portable railings in place. Where the nature of the work is such that fixed railings are impracticable, removable railings should be used.

Fig. 1 shows a removable wooden railing supported by sockets.

Fig. 4 shows chains, fastened permanently at one side of the doorways and connected with hooks at the other. Pipe railings may be made portable by supporting them in sockets or on fixed studs.

Fig. 3. Structural Steel Stairway for Coal Hoist.†

Fig. 4. Doorways protected by chains.*

Ladders are commonly used in such locations as that shown in Fig. 3. The greater safety and convenience of the stairway, however, are sufficient to justify its additional cost.

* Courtesy of the American Steel Foundries Company.

† Courtesy of the American Steel and Wire Company, subsidiary of the United States Steel Corporation.

on the other side. Such panels should be glazed with wired glass.

Where door-knobs are used on swinging doors, there should be sufficient clearance to prevent jamming a hand between knob and side of doorway.

Horizontally sliding doors of heavy construction should have some positive arrangement to prevent the possibility of their becoming misplaced and falling. This may be accomplished by installing the doors in such a manner that the distance between the under side of the track and the top of the door is less than the depth of the wheel grooves; if the door is then forced upward, it will be stopped by the under edge of the track before the wheel can be thrown off.

This arrangement is contemplated in the installation of standard sliding fire doors. A case occurred in a Massachusetts plant, however, in 1914, where a fire door, in being pushed shut, was lifted from the track by a small piece of pipe on the floor underneath the door. The falling door pinned a watchman beneath it, and so stunned or paralyzed him that he was unable to free himself. He was dead when found by the next watchman. (See October, 1914, Quarterly of the National Fire Protection Association.)

Vertically sliding doors of heavy construction are usually counterweighted. A serious accident may result if the counterweight should become detached and allow the door to drop. The rules of the National Board of Fire Underwriters call for two counterweights for vertically sliding fire doors. One counterweight is to be permanently connected by a wired cable to the top of the door and is to be of such size as to prevent the door from dropping suddenly. This allows the door to lower gradually, however, when the second counterweight, smaller than the first, is released by the melting of a fusible link.

Where vertically sliding doors are not intended for use as fire doors, it is well to have two counterweights, about equal in size, independently attached to the door. With this arrangement, if one of the counterweight supports should break while the door is being raised or lowered, the entire weight of the door will not be brought to bear on the person who is manipulating it. A positive catch which will hold the door in its upper position is also desirable, to prevent sudden lowering of the door if a counterweight should be released. Door counterweights should be guarded, as specified elsewhere for "Counterweights."

SKYLIGHTS

Skylights are often provided in locations where persons must work or pass underneath them. In such cases it is evident that injuries may result if the glass should break and fall. It is accordingly desirable to used wired glass in all such locations, since wired glass may be badly shattered without permitting any pieces to fall.

Rules of the National Board of Fire Underwriters for skylights require all skylights, except those glazed with wired glass or with glass one-half inch thick or over and inclined at an angle of more than 45°, or vertical, to be protected by screens of galvanized steel wire cloth. (See Fig 2, P. 338.) The cloth is to be of not less than 12 ga. wire, not over 1" mesh, framed, secured and supported in an approved manner.

While these guards are intended primarily to prevent burning embers from falling through the skylight and starting a fire, they have a certain value from the accident prevention standpoint in preventing breakage of the glass.

WINDOW CLEANING

Sometimes arrangements can be made to clean monitor windows from adjacent flat roofs. In other cases, platforms may be provided for this purpose inside the windows; such platforms may be made of heavy woven wire fabric which does not interfere appreciably with the light. Where windows in mill buildings are adjacent to crane runways, a railing or barrier that will prevent the window cleaner from getting in a position where he might be struck by a traveling crane, should be erected.

Where windows are to be cleaned by standing on the sills, suitable hooks or eyes should be provided at the sides of each window, into which the attachments of a safety belt may be snapped. These hooks or eyes should be sufficiently heavy that their strength will not be seriously impaired by corrosion during a period of years, and they should be securely fixed in position.

PROTECTION FROM SNOW ON ROOF

Where the pitch of a roof is such that snow-slides may occur and injure passersby on the ground below, some arrangement should be made to prevent accidents. A barrier may be placed at the edge of the roof, or clips may be inserted at frequent intervals in the roof which will prevent a slide from starting.

PASSAGEWAYS, ETC.

In installing additional machinery, there is often a tendency to encroach on passageways and reduce the clearance between machines. This increases the accident hazard.

Ample passageways should be maintained at all times. Where trucks are used, all main passageways should be wide enough to permit two trucks to pass freely. The proper space allowance varies with different industries and local conditions, but in general, a minimum clear space of at least 4′ is recommended for aisles and passageways, and at least 2′ where men must pass between machines.

CHAPTER II

BOILER EQUIPMENT, ETC.

EXPLOSIONS OF BOILERS AND OTHER STEAM APPARATUS

BOILER explosions may result from a number of causes, chief among which are defective design, faulty construction and improper operation. The following table, taken from data published by the British Government,* is of interest as it gives actual data on a large number of accidents to steam apparatus. These accidents illustrate most of the common causes of failure.

* See Annual Reports to the London Board of Trade on the workings of the Boiler Explosion Act.

CAUSES OF 206 EXPLOSIONS OF STEAM BOILERS AND OTHER APPARATUS USING STEAM DURING THE YEARS 1911 AND 1912

Type of Equipment	*High Pressure Boilers*	*Heating Boilers, etc.*	*Economizers*	*Tubes in Steam Ovens*	*Calenders, Drying Cylinders, etc.*	*Hot Plates, etc.*	*Rag Boilers, Kiers, Stills, etc.*	*Steam Jacketed Pans*	*Steam Pipes, Valves, etc.*	*Steam Separators*	*Misc.*	*Total*
Defective design	—	—	1	5	—	—	—	—	2	—	3	11
Defective workmanship, material, etc.	3	—	—	1	—	1	—	—	14	1	1	21
Deterioration or Corrosion	37	—	1	4	1	1	1	1	6	—	1	53
Low Water	7	2	—	—	—	—	—	—	1	—	—	10
Overheating	1	—	—	14	—	—	—	—	—	—	—	15
Overheating from Scale, Rust, Ice, etc.	5	10(b)	—	—	—	—	—	—	—	—	—	15
Overpressure	3	—	—	—	8	3(f)	4	9	1	1	7	36
Failure of Bolts, Rivets, etc.	6	—	2(c)	—	—	—	—	—	—	—	—	8
Water Hammer	—	—	—	—	1	—	—	—	20	—	—	21
Miscellaneous	5(a)	—	1	1(d)	1(e)	—	—	1(d)	7(g)	—	—	16
Total	67	12	5	25	11	5	5	11	51	2	12	206

a. One of these was a lap weld failure.
b. Nine of these due to pipes being blocked with ice.
c. Due to tightening bolts under pressure.
d. Defective weld.
e. Gland nut worked loose.
f. One of these due to inoperative condition of safety valve and reducing valve on inlet, and one due to pipes being blocked with ice.
g. Excessive vibration or fatigue.

The 206 accidents included in the above list caused the death of 43 persons, and the injury of 136 more. These were distributed as follows:

Kind of Equipment	*No. of Explosions*	*Persons*	
		Killed	*Injured*
High Pressure Boilers	67	8	46
Heating Boilers, etc.	12		10
Economizers	5	3	3
Tubes in Steam Ovens	25		4
Calenders, Drying Cylinders, etc.	11	2	7
Hot Plates, etc.	5		3
Rag Boilers, Kiers, Stills, etc.	5	3	6
Steam Jacketed Pans	11	3	13
Steam Pipes, Stop Valve Chests, etc.	51	23	34
Steam Separators	2	1	
Miscellaneous	12		10
Total	206	43	136

The precautions necessary to avoid accidents from the above-mentioned causes are more or less obvious to persons familiar with the use of steam apparatus, but may be briefly outlined as follows: —

Defective workmanship. The purchaser of a boiler should have the work of constructing and erecting it supervised by a competent inspector, to avoid defective workmanship.

Deterioration, corrosion, erosion, etc., can usually be detected by proper inspection, before the condition becomes dangerous.

Low water, over-heating, over-pressure, etc., generally indicate carelessness on the part of those responsible for the care of the equip ment. In fact, 38 out of the total of 206 accidents were charged to the ignorance or neglect of attendants, in one form or another.

Excessive pressure is a common cause of accidents in calenders, steam ovens, hot plates and other steam-heated devices. This usually results from failure of the reducing valve, or safety valve, or both. Where reduced pressure is used, pop safety valves with lifting device, and steam gages, should be provided on the low-pressure side of the line; these should be inspected and tested at regular intervals and the necessary oversight should be given to make sure that they are in satisfactory operating condition at all times.

The pipe used to supply live steam for such service should be as small as practicable. The safety valve (or valves) should be of ample capacity to prevent pressure building up in case the reducing valve should fail.

Where the live steam supply pipe is necessarily a large one, it may be undesirable to permit safety valves to open suddenly to the full capacity of the pipe, on account of danger to the boiler from the sudden release in pressure which would result. For such conditions the use of an automatic stop valve, operated by a pilot valve which will cause the automatic valve to close and shut off the supply of steam in case excessive pressure should develop on the low-pressure side, is recommended. (See Fig. 1, P. 79.)

Nine of the explosions from heating apparatus mentioned in the above table occurred during a spell of extreme cold weather, which caused the pipes to be obstructed by ice.

Over-heating from scale may be prevented by cleaning and blowing down the boiler at proper intervals. If there is excessive formation of scale, some special action may be necessary, such as filtering the feed water to remove suspended solids, or treating it chemically to render the scale-forming compounds soluble or readily removable.

Where chemical treatment is resorted to, it should be based on an actual analysis of the particular water in question, since the conditions causing this trouble are exceedingly variable. The "cure-all" type of boiler compounds, which are advocated as meeting all conditions satisfactorily, should be avoided.

Soda ash is the principal agent of value for treating boiler feed water. Since it is alkaline in reaction, it neutralizes any acids which may be present. It also tends to prevent the formation of, and to assist in the removal of, the troublesome lime and magnesia scales.*

Oil in the feed water is very objectionable, since it may collect in spots on the inside of the boiler, preventing the proper conduction of heat and causing overheating and bagging of the plate.

Work on apparatus under pressure. Several of the accidents listed above occurred from tightening bolts in steam apparatus while it was under pressure. This is a dangerous practice and should never be permitted, since the bolts, already heavily stressed, may give way without warning, under the wrench. It is also hazardous to calk or hammer steam piping or equipment in any way while under pressure.

Apparatus out of order. Several accidents were caused by the sticking of safety valves, traps, etc., showing the need of closer supervision.

Water-hammer usually occurs from water collecting in pipes and not being properly removed before valves are opened, or from valves being opened or closed too suddenly. The use of drips (with or without steam traps), and care in operating valves, will prevent such accidents. By-passes are recommended for large valves, to facilitate gradual opening and to prevent sticking.

Hazard of Low-Pressure Units

Numerous accidents in this country corroborate the British experience as to the danger from small low-pressure steam and hot water units. The ordinary water heater has possibilities of disaster which are not generally realized by those who have not had an immediate demonstration of this fact. (See Fig. 3, P. 85.)

* For a discussion of Boiler Feed Water, see chapter on Corrosion and Incrustation, "Steam Boilers," Peabody and Miller.

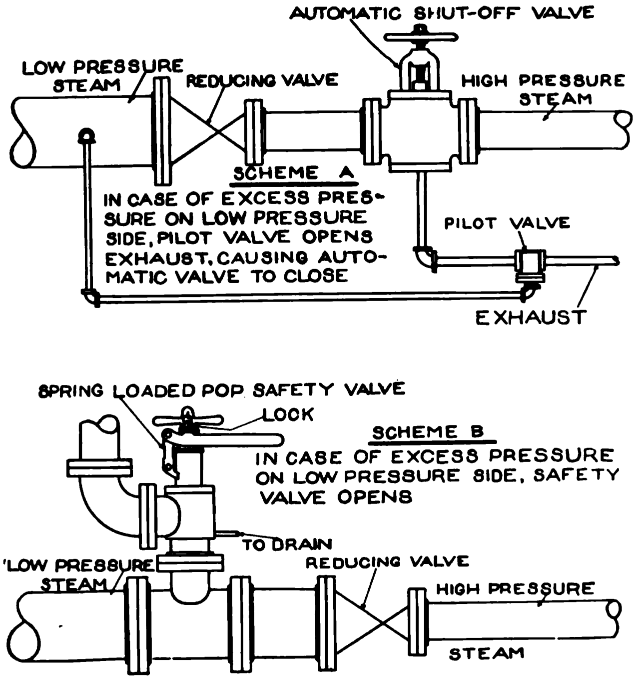


Fig. 1. Reducing Valve Installations for Equipment using Low-Pressure Steam.

Fig. 2. In-swinging Furnace Doors, in Plant of Carnegie Steel Company.*

Fig. 3. Valve-Locking Device and Stencil for marking Main Steam Valve of Boiler.*

Fig. 1 shows two arrangements for protecting low-pressure equipment using steam from high-pressure lines, through a reducing valve. (See "Excessive Pressure," Page 78.)

Fig. 2 is a photograph of an installation of in-swinging furnace doors in a boiler plant. These doors will check the rush of steam from bursting tubes, etc., and may thus prevent serious injuries to firemen.

Fig. 3 shows a hinged circular box for locking valves, to protect men working inside boilers or other equipment. The box can be locked in position around hand-wheel, making it impossible to open the valve.

Devices of this type should be provided in boiler-houses, pump-rooms, etc., to be placed on controlling-valves of boilers, heaters, filter-tanks, or any similar places where men might be scalded if a valve were opened by mistake. When a boiler is taken off the line, the crown valve, feed-water, and blow-off valves should be locked, and the locks should not be removed until the boiler is ready to be placed in service again.

This device can also be used on engine throttle valves, the valve wheels controlling turbines, etc. For such purposes the wording is "Danger, do not start." The box is made of steel (about 20 ga.).

The stenciled numbers shown in this illustration can be distinguished by touch in case the lights should go out.

* Courtesy of the United States Steel Corporation.

Even the innocent-looking peanut roaster has been responsible for at least three fatalities during the past few years. (See "The Locomotive," July, 1913, page 207.)

The explosive power of boilers having a low horse power rating is admirably brought out in a paper entitled, "Steam Boilers as Magazines of Explosive Energy," by Robert H. Thurston, presented before the American Society of Mechanical Engineers and appearing in Volume VI of the "Proceedings" (for the years 1884 and 1885).

In this paper Mr. Thurston called attention to the fact that the greater portion of the energy which may be released by the explosion of a steam boiler, is contained in the latent heat of the water, and only a small portion of it is due to the steam which has been actually vaporized.

He showed that a cubic foot of heated water under a pressure of 60 to 70 pounds per square inch has about the same energy as a pound of gun-powder. He made a series of calculations for various types of boilers showing the relative stored energy in the water and steam space, and the height to which this energy would project the boiler if it were all utilized in this way. Abstracts from these tables are here reproduced.

It will be noted that the 10 H.P. cylindrical boiler at 100 lbs. pressure contains almost one-half the available energy of the 200 H.P. return tubular boiler at 30 lbs. This energy would be sufficient to throw the boiler nearly four miles into the air, with an initial velocity of 1100 feet per second.

Mr. Thurston cites a case which came under his personal observation, where a boiler of this type exploded. The end of the boiler was driven through a 16-inch brick wall and carried several hundred feet through the air, cutting off an elm tree at a point where it measured nine inches in diameter; it was found red hot after it struck the earth.

He cites another interesting case where a boiler was exploded under steam, by Mr. S. B. Stevens, at Sandy Hook, November, 1871. This boiler was tested to fifty-nine pounds by hydrostatic pressure before its explosion, but it actually failed at fifty-three and one-half pounds steam pressure. The boiler was thrown to a height estimated at from two to four hundred feet, and fell at a distance of four hundred and fifty feet from its original position.

TOTAL AVAILABLE ENERGY IN WATER AND STEAM (IN FOOT-POUNDS)

Absolute pressure lbs. per square inch	*Gage pressure*	*Temperature degrees Fahrenheit*	*Energy in 1 lb. water which may be liberated by explosion*	*Corresponding energy in latent heat of evaporation*	*Total energy in 1 lb. steam, corresponding temperatures*
20	5.3	227.9	145.9	16,872.9	17,018.8
25	10.3	240.0	439.7	29,156.8	29,596.5
65	50.3	297.7	3,899.8	78,850.5	82,750.3
115	100.3	337.8	8,087.3	106,421.7	114,509.0
165	150.3	365.7	11,823.4	122,697.8	134,521.2

TOTAL STORED ENERGY OF STEAM BOILERS

Number	*Type*	*Press. lbs. sq. in.*	*Rated H.P.*	*Weight of*		*Stored Energy Available*	*Max. height of projection Feet*	*Initial Velocity Feet per second*
				Boiler lbs.	*Water lbs.*			
1	Plain Cylind. . .	100	10	2,500	5,764	47,281,898	18,913	1,103
5	Locomotive. . . .	125	525	19,400	5,260	54,044,971	2,786	423
9	Scotch Marine .	75	300	27,045	11,765	72,734,800	2,689	416
11	Ret. Tub.	30	200	56,000	42,845	92,101,987	1,644	325
13	Water Tube. . .	100	250	34,450	21,325	174,563,380	5,067	571
14	Water Tube. . .	100	250	45,000	28,115	230,879,830	5,130	575

Fortunately, in an actual boiler explosion, the total available energy is seldom liberated all at once; a break in a boiler quickly reduces the pressure, and if the opening is not too large, and the adjacent parts are sufficiently strong to prevent the opening from spreading, the water and steam may be blown out through the aperture without doing a great deal of damage. Herein lies the superiority, from the safety standpoint, of the water tube boiler. The water space is so subdivided that only a limited portion of the structure is usually affected by a break.

While it is impossible, to absolutely prevent all boiler explosions by human skill and foresight, the likelihood of their occurring can be largely reduced by care in operation, and thorough inspection at regular intervals. The Boiler Insurance companies perform a valuable function in the way of preventing explosions, through the supervision by trained inspectors which they afford. This alone makes boiler insurance desirable, aside from the value of such insurance in taking care of the financial loss which results when a boiler explosion does occur.

SAFETY PROVISIONS FOR BOILER EQUIPMENT

The detailed precautions which should be taken for the prevention of accidents from boiler equipment will be discussed under three headings, viz: —

(1) **Boiler Construction,** covering the boiler proper, which is usually purchased from an outside builder.

(2) **Boiler Plant Design,** covering the general arrangement and construction of the plant, with its piping, walks, stairways, etc.

(3) **Safety Rules for Boiler Operation,** giving rules to be observed by the men who are in charge of a plant after it has been placed in service, and safety conditions to be maintained.

Boiler Construction

A committee known as the "Boiler Code Committee" of the American Society of Mechanical Engineers, appointed September 15, 1911, to "Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for Care of Same in Service" submitted its final report February 13, 1915. This report contains detailed specifications for the materials to be used in the construction of stationary boilers, and rules for the design and installation of such boilers.

These specifications and rules undoubtedly represent the best general standards which have yet been developed for such equipment. It is accordingly recommended that in ordering new boilers the purchaser specify that they shall conform fully to the standards of the Boiler Code Committee of the A.S.M.E. (except that, if there should be any direct conflict between these Standards and State laws or local ordinances for the community in which the boilers are to be operated, the latter should take precedence.)*

The report of the Boiler Code Committee is divided into two parts. Part I contains some 80 pages, devoted to specifications for materials and rules for new boiler installations. These are chiefly matters which should be taken care of by the boiler constructor, and will not be given further space here. Copies of the complete report can be purchased from the Society.

In general, the safety inspector and others interested in safe working conditions for industrial plants have to do chiefly with existing installations. Such installations are covered in Part II of the Report, which is re-printed below, by permission of the Society: —

Existing Installations

Maximum Allowable Working Pressure

378. The maximum allowable working pressure on the shell of a boiler or drum should be determined by the strength of the weakest course, computed from the thickness of the plate, the tensile strength of the plate, the efficiency of the longitu-

* The State of Massachusetts has had an excellent set of Boiler Rules in operation for a number of years. These rules, and the standards adopted by some large industrial concerns for their own use, go farther, in certain respects, than those formulated by the A.S.M.E. committee. Among these the following important features may be mentioned: —

Fusible Plugs are required by the Massachusetts rules. These are to be filled with pure tin and of not less than $\frac{1}{2}$″ inside diameter except for working pressures of more than 175 lbs., or when placed in a tube, in which cases the diameter of fusible metal is to be not less than $\frac{3}{8}$″. The location of the fusible plug is specified in the rules for some twenty types of boilers, the specification ending with the following general clause:

"For other types and new designs, fusible plugs shall be placed at the lowest permissible water level, in the direct path of the products of combustion, as near the primary combustion chamber as possible."

No fusible plug should be used for a longer period than one year.

Use of Cast Iron. The Boiler Code Committee limits the pressure allowed on a low-pressure heating boiler constructed wholly of cast iron, to 15 lbs. per square inch, and limits the pressure on a high-pressure boiler, the tubes of which are secured to cast iron headers, to 160 lbs. per square inch.

The standard requirements of the U.S. Steel Corporation for high-pressure boilers prohibit the use of cast iron in any part subject to steam pressure. In view of the well-known limitations of cast iron, this prohibition appears to be justifiable.

Dry Plates. The U.S. Steel Corporation requirements call for a dry-plate (or dry-pipe,— preferably the former) in the drum of each boiler, under the steam nozzle, extending about 3′ on each side of the nozzle and located about 8″ from the top of the shell.

Manhole and Handhole Plates. A superior safety condition is secured where manhole and handhole plates in headers and water-legs of water tube boilers and economizers, are of inside type. Fatal accidents have resulted from the failure of bolts, where outside type plates were used.

dinal joint, the inside diameter of the course and the factor of safety allowed by these rules.

$$\frac{TS \times t \times E}{R \times FS} = \text{maximum allowable working pressure, lbs. per sq. in. where}$$

TS ultimate = tensile strength of shell plates, lbs. per sq. in.
t = thickness of shell plate, in weakest course, in.
E = efficiency of longitudinal joint, method of determining which is given in Par. 181, of these Rules.*
R = inside radius of the weakest course of the shell or drum, in.
FS = factor of safety allowed by these Rules.

379. Boilers in service one year after these Rules become effective shall be operated with a factor of safety of at least 4 by the formula, Par. 378. Five years after these Rules become effective, the factor of safety shall be at least 4.5. In no case shall the maximum allowable working pressure on old boilers be increased, unless they are being operated at a lesser pressure than would be allowable for new boilers, in which case the changed pressure shall not exceed that allowable for new boilers of the same construction.

(Author's note.) The lowest factor of safety permitted by the Massachusetts Rules, applicable to boilers with butt and double-strap longitudinal joints only, is 4.5. For boilers with longitudinal lap joints not exposed to products of combustion the minimum factor is 5; exposed to products of combustion, — 5 for boilers over 10 years old; 5.5 for boilers of 10 to 15 years, inc.; 5.75 for boilers of 15 to 20 years, inc.; 6 for boilers over 20 years. The requirements of the U.S. Steel Corporation do not permit a lower factor of safety than 5, on any type of boiler construction.

380. The age limit of a horizontal return tubular boiler having a longitudinal lap joint and carrying over 50 lbs. pressure shall be 20 years, except that no lap joint boiler shall be discontinued from service solely on account of age until 5 years after these Rules become effective.†

* Paragraph 181 reads as follows: "*Efficiency of a Joint.* The efficiency of a joint is the ratio which the strength of the joint bears to the strength of the solid plate. In the case of a riveted joint this is determined by calculating the breaking strength of a unit section of the joint, considering each possible mode of failure separately and dividing the lowest result by the breaking strength of the solid plate of a length equal to that of the section considered."

† Lap joints have been responsible for serious boiler explosions. (See Page 16.) Paragraph 187 of the Rules restricts the use of longitudinal lap joints in new installations to boilers 36" or less in diameter. Paragraph 188 limits the pressure on boilers having longitudinal lap joints to 100 lbs. per sq. in.

381. Second-hand boilers, by which are meant boilers where both the ownership and location are changed, shall have a factor of safety of at least $5\frac{1}{2}$, by the formula Par. 378, one year after these Rules become effective, unless constructed in accordance with the Rules contained in Part I, when the factor shall be at least 5.

382. **Cast-Iron Headers and Mud Drums.** The maximum allowable working pressure on a water tube boiler, the tubes of which are secured to cast-iron or malleable iron headers, or which have cast-iron mud drums, shall not exceed 160 lbs. per sq. in.

383. **Steam Heating Boilers.** The maximum allowable working pressure shall not exceed 15 lbs. per sq. in. on a boiler used exclusively for low pressure *steam* heating.

(Author's note.) The revised Massachusetts Rules require an independent stop valve and check valve in the return pipe to each boiler, where there are two or more connected boilers (Gravity Return System).

Typical examples of various forms of joints, calculations of which are given in the appendix to the Rules, show the following results:

Lap joint, single-riveted	.576 efficiency
Lap joint, double-riveted	.739
Butt and double-strap joint, double-riveted	.820
Butt and double-strap joint, triple-riveted	.875
Butt and double-strap joint, quadruple-riveted	.937
Butt and double-strap joint, quintuple-riveted	.963

384. No pressure shall be allowed on a boiler on which a crack is discovered along the longitudinal riveted joint.

Strength of Materials

385. ***Tensile Strength.*** When the tensile strength of steel or wrought-iron shell plates is **not** known, it shall be taken as 55,000 lb. per sq. in. for steel and 45,000 lb. for wrought-iron.

386. ***Strength of Rivets in Shear.*** In computing the ultimate strength of rivets in shear the following values in pounds per square inch of the cross-sectional area of the rivet shank shall be used:

Iron rivets in single shear	38,000
Iron rivets in double shear	76,000
Steel rivets in single shear	44,000
Steel rivets in double shear	88,000

The cross-sectional area shall be that of the rivet shank after driving.

387. ***Crushing Strength of Mild Steel.*** The resistance

to crushing of mild steel shall be taken at 95,000 lb. per sq. in. of cross-sectional area.

TABLE 10. — SIZES OF RIVETS BASED ON PLATE THICKNESS

Thickness of plate............	1/4"	9/32"	5/16"	11/32"	3/8"	13/32"
Diameter of rivet after driving..	11/16"	11/16"	3/4"	3/4"	13/16"	13/16"

Thickness of plate............	7/16"	15/32"	1/2"	9/16"	5/8"
Diameter of rivet after driving..	15/16"	15/16"	15/16"	1 1/16"	1 1/16"

388. ***Rivets.*** When the diameter of the rivet holes in the longitudinal joints of a boiler is **not** known, the diameter and cross-sectional area of rivets after driving may be ascertained from Table 10, or by cutting out one rivet in the body of the joint.

Safety Valves for Power Boilers

389. The safety valve capacity of each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent above the maximum allowable working pressure, or more than 6 per cent above the highest pressure to which any valve is set.

390. One or more safety valves on every boiler shall be set at or below the maximum allowable working pressure. The remaining valves may be set within a range of 3 per cent above the maximum allowable working pressure, but the range of setting of all of the valves on a boiler shall not exceed 10 per cent of the highest pressure to which any valve is set.

391. Safety valve capacity may be checked in any one of three different ways, and if found sufficient, additional capacity need not be provided:

(*a*) By making an accumulation test, by shutting off all other steam discharge outlets from the boiler and forcing the fires to the maximum. The safety valve equipment shall be sufficient to prevent an excess pressure beyond 6 per cent as specified in Par. 389.

(*b*) By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel. See Appendix, Pars. 421 to 427.

(c) By determining the maximum evaporative capacity by measuring the feed water. The sum of the safety valve capacities shall be equal to or greater than the maximum evaporative capacity of the boiler.

392. In case either of the methods outlined in sections *b* or *c* of Par. 391 is employed, the safety valve capacities shall be taken at the maximum values given in Table 8 for spring loaded pop safety valves, or 0.66 times the maximum values given in Table 8, for lever safety valves.

393. When additional valve capacity is required, any valves added shall conform to the requirements in Part I of these Rules.

394. No valve of any description shall be placed between the safety valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. When a discharge pipe is used, it shall be not less than the full size of the valve, and the discharge pipe shall be fitted with an open drain to prevent water lodging in the upper part of the safety valve or in the pipe. If a muffler is used on a safety valve it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid any possibility of restriction of the steam passages due to deposit. When an elbow is placed on a safety valve discharge pipe, it shall be located close to the safety valve outlet or the pipe shall be securely anchored and supported. All safety valve discharges shall be so located or piped as to be carried clear from running boards or working platforms used in controlling the main stop valves of boilers or steam headers.

Fittings and Appliances

395. ***Water Glasses and Gage Cocks.*** Each steam boiler shall have at least one water glass, the lowest visible part of which shall be not less than 2 in. above the lowest permissible water level.

396. Each boiler shall have three or more gage cocks, located within the range of the visible length of the water glass, when the maximum allowable working pressure exceeds 15 lb. per sq. in., except when such boiler has two water glasses with independent connections to the boiler, located on the same horizontal line and not less than 2 ft. apart.

397. No outlet connections, except for damper regulator, feed-water regulator, drains or steam gages, shall be placed on the pipes connecting a water column to a power boiler.

398. ***Steam Gages.*** Each steam boiler shall have a steam gage connected to the steam space or to the water column or to its steam connection. The steam gage shall be connected to a syphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open. Connections to gages shall be of brass, copper or bronze composition.

399. ***Stop Valves.*** Each steam outlet from a

power boiler (except safety valve connections) shall be fitted with a stop valve located as close as practicable to the boiler.

400. When a stop valve is so located that water can accumulate, ample drains shall be provided.

401. ***Bottom Blow-Off Pipes.*** Each boiler shall have a blow-off pipe fitted with a valve or cock, in direct connection with the lowest water space practicable.

402. When the maximum allowable working pressure exceeds 125 lb. per sq. in., the blow-off pipe shall be extra heavy from boiler to valve or valves, and shall run full size without reducers or bushings. All fittings between the boiler and valve shall be steel, extra heavy malleable iron or extra heavy cast-iron.

403. When the maximum allowable working pressure exceeds 125 lb. per sq. in., each bottom blow-off pipe shall be fitted with an extra heavy valve or cock. Preferably two (2) valves, or a valve and a cock should be used on each blow-off in which case such valves, or valve, and cock, shall be extra heavy.

404. A bottom blow-off pipe when exposed to direct furnace heat, shall be protected from the products of combustion by fire-brick, a substantial cast-iron removable sleeve, or a covering of non-conducting material.

405. An opening in the boiler setting for a blow-off pipe shall be arranged to provide for free expansion and contraction.

406. ***Feed Piping.*** The feed pipe of a steam boiler operated at more than 15 lbs. per sq. in. maximum allowable working pressure, shall be provided with a check valve near the boiler and a valve or cock between the check valve and the boiler, and when two or more boilers are fed from a common source, there shall also be a globe valve on the branch to each boiler, between the check valve and the source of supply. When a globe valve is used on a feed pipe, the inlet shall be under the disc of the valve.

407. ***Lamphrey Fronts.*** Each boiler fitted with a Lamphrey boiler furnace mouth protector, or similar appliance, having valves on the pipes connecting them to the boiler, shall have these valves locked or sealed *open*. Such valves, when used, shall be of the straightway type.

Hydrostatic Pressure Tests

408. ***Test Pressure.*** When a hydrostatic test is applied the required test pressure shall be one and one half times the maximum allowable working pressure. The pressure shall be under proper control so that in no case shall the required test pressure be exceeded by more than 2 per cent.

409. During a hydrostatic test of a boiler, the safety valve or valves shall be removed or each valve disc shall be held to its seat by means of a testing clamp and not by screwing down the compression screw upon the spring.

Aside from the construction of the boiler proper, many important safety provisions should be made in laying out the boiler plant and its auxiliary equipment. The proper operation of the plant after it is placed in service is also of great importance.

The following material (in slightly modified form) was embodied in a paper by the author presented before the Engineers' Society of Western Pennsylvania in March, 1912.* The material for this paper was accumulated over a period of years, much of it being obtained from data prepared by the Steam Engineers' Committee of the United States Steel Corporation, which made a report on the subject to the Corporation's Committee of safety at about that time.

BOILER PLANT DESIGN

Platforms, Stairways, and Lighting

(*a*) A system of walks or runways should be erected to give convenient access to overhead valves, water columns, etc. Passageways from boiler to boiler should also be provided. Suitable platforms should be erected at main emergency valves from which they can be safely operated, unless such valves are arranged for floor operation. (See Fig. 1, P. 85.)

(*b*) Walks and platforms should be well lighted and free from breaks or obstructions which might interfere with their use. They should be equipped with standard handrails and toe-boards.

(*c*) Walks and stairways should preferably be of steel construction, checkered steel plate being recommended for flooring. Such plate should be not less than $\frac{3}{16}''$ thick, and it should be perforated with holes not larger than $\frac{11}{16}''$ spaced about 12'' centres, for drainage purposes.

(*d*) Wherever possible, railed stairways should be used in preference to ladders.

(*e*) Means of egress should be provided for overhead walks at both ends of each line of

* See Proceedings for April, 1912, pages 143–165.

Fig. 1. Foot-walks and Runways in Boiler Plant.*

Fig. 2. Overhead Coal-Bin in which Man was Suffocated.

Fig. 3. Explosion of Low-Pressure Heating Boiler.

Convenient access should be provided for main steam valves in boiler plants, since they may have to be operated when the building is filled with escaping steam (the possibility of such accidents is reduced considerably by the use of "non-return" valves, see Page 87). Walks should be well lighted, and free from breaks or obstructions. Two or more points of access should be provided for such walks, as well as for underground ash tunnels, stairways being preferable to ladders.

In Fig. 1 a stairway will be noted at the far end of the boiler plant, and another between the first and second boilers, at the near end; the runway extends directly through the building, with a third stairway outside. Attention is directed to the escape-pipes from safety valves, which extend vertically through the roof.

The hazard from handling fine coal should be kept in mind. Fig. 2 shows an overhead supply bin in which a man was suffocated while "trimming" coal. The coal, which had bridged over, suddenly gave way and carried him down with it. Suitable walkways should be provided over, or along the sides of such bins, from which men can work in safety.

Fig. 3 illustrates a wreck caused by an ordinary low-pressure heating boiler; such boilers should always be equipped with some form of relief valve, the latter being inspected at regular intervals to see that it is in satisfactory operating condition. A check valve should never be placed in the connection to such boilers, in a way that will prevent the flow of water from boiler to supply line in case of over-pressure.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

boilers. In large plants, one or two intermediate means of escape may be needed.

(*f*) It is very desirable to have red incandescent lamps suspended near important cut-off valves or branches from steam mains or headers, thus favoring ready access to same in case of emergency.

(*g*) A shaded light, preferably an incandescent lamp, should be suspended near each water column, so as to render the water-level clearly visible.

(*h*) Special attention should be given to securing good illumination throughout the boiler house. Unless the illumination is exceptionally good it is advisable to have at least one light at each of the stairways leading to overhead platforms, particularly at the upper end of the main stairways. It is desirable to have emergency lights available at all times, arranged so they can be turned on quickly in case the regular lights should fail.

Steam Pipe Expansion

System of steam piping should be laid out with great care to avoid danger from expansion and contraction. The expansion should be taken care of preferably by loops or bends, or if necessary, by expansion joints. In all cases the *anchorage* of the piping is just as important as the loops or bends. The pipe system should be anchored at certain points in such a way that these points will be absolutely fixed, and that the expansion will be away from the points of anchorage, toward a loop, bend or expansion joint. It is particularly necessary to see that this expansion does not throw any undue strain on any part of the piping system, or on boiler fittings, steam chests of engine cylinders, etc., to which the pipes are connected.

Steam Mains and Connections

(*a*) Steam headers receiving the steam from several boilers should be placed at a sufficient distance from the nozzles of the boilers to permit the use of "goose-neck" connections, capable of considerable expansion without introducing dangerous stresses on flanges or nozzles. A straight connection from the boiler nozzle to the steam header is to be avoided at all times. Goose-neck connections to the side of a header may be used, but the top connection (that is, connection on header vertical) is preferred. Connection to bottom of header is a dangerous construction, and should not be used. Headers should slope in the direction of steam flow, for drainage purposes, at a grade of not less than 10″ in 100′ and preferably somewhat more.

(*b*) Drain pipes should be connected to the goose-necks (and to any other places where water-pockets are formed) at the proper place to prevent pocketing of water when valve is shut. These should lead to receivers or traps for the automatic removal of water that may collect and the outlets should be so placed that water cannot return through the drain pipes.

(*c*) Where heavy pulsations of the steam currents cause excessive vibration, reservoirs should be inserted in the steam mains.

(*d*) Where main lines branch, or a distributing pipe leads off from the main line, a valve should be placed in same close to the connection, so that the branch line can be shut off independently.

Stop Valves

(*a*) A gate stop valve of approved construction should be set at the outer extremity of the goose-neck connection to the boiler, and as near the steam header as possible. In all cases the valve stem should have its threads outside of the valve casing.

(*b*) A non-return valve (preferably of the triple-acting type) should be provided for each boiler, where two or more boilers are connected into the same piping system. This valve should be set in the goose-neck connection, as near to the boiler nozzle as practicable. Where a pilot valve is used in connection with the non-return valve, it should be connected up so that both valves can be readily tested, to make sure that they are in satisfactory operating condition.

Safety Valve Connections

(*a*) Each safety valve should have a vertical escape-pipe, with an outlet through the roof of the boiler house wherever practicable.* The

* Horizontal escape pipes from safety valves are to be avoided, as they produce an undesirable and frequently dangerous thrust on the boiler nozzle when a violent escape of steam occurs.

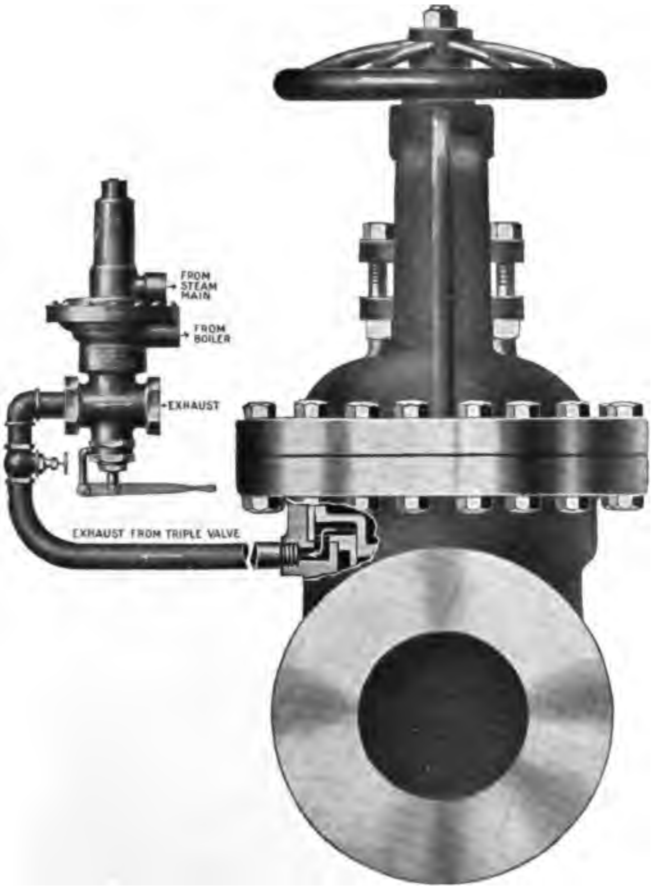


Fig. 1. Triple-Acting " Non-Return " Valve.

Fig. 2. Valve equipped for Floor Operation.*

When a break occurs in a boiler or its piping system, the release in pressure causes the water remaining in the boiler to flash into steam. Where several boilers are connected in one battery, the danger from this condition is accentuated by the large volume of water in the system. In order to cut out the boiler, the boiler-house attendants may run considerable risk in reaching the valves, if hand-operated valves are used.

To overcome this danger, valves have been developed which close automatically in case of accident. These are of two general types, — (1) the simple non-return valve which is, in effect, a check-valve to prevent steam from flowing back into any boiler in which a break has occurred (the valve can also be closed by hand), and, — (2) the triple-acting valve, which has the additional feature of closing in case there is a break in the steam line. This is accomplished by the use of a pilot valve as shown in Fig. 1.

Where triple-acting valves are used, and it is not considered advisable to have them close automatically when the line pressure drops, the exhaust pipes from all valves may be connected together and lead to an emergency pilot valve outside the plant (preferably in the office of engineer, master-mechanic, etc.), from which the triple-acting valves may be closed by hand in case of accident.

Fig. 2 shows a good safety provision, which permits emergency valves to be closed without the delay and hazard incident to the use of ladders. It is important to have guides for the chain, otherwise it may be thrown off the wheel at a critical time. Sometimes a geared or direct-connected rod may be used advantageously instead of the chain.

*** Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.**

arrangement should never be such that persons on walks or platforms adjacent to safety valves may be scalded by a sudden escape of steam.

(*b*) Drain pipes should be attached to escape pipes from safety valves, as near as possible to the valve proper. These drains should be open connections discharging at some point where they will not cause injury, but will be available for inspection.

Water Column and Gage Glasses.

(*a*) Each water column should be provided with a drain connection having an open end in the ash pit. The pipe used for this connection should be of sufficient size to permit any foreign material that may enter the column being blown out (say $\frac{3}{4}''$ to $1''$ dia.). To facilitate cleaning, crosses with plugs should be used in water column connections in preference to ells.

(*b*) **The try cocks** on the water column should be connected by rods to handles readily accessible from boiler-room floor or operating platform, as is most convenient for manipulation by the water tender.

(*c*) Gage glass valves should have rod connections, by means of which they can be readily shut off from floor or platform. They should be so designed that they can be packed under pressure and arranged to give a full opening or closing movement by pulling operating rods. (See Fig. 2, P. 89.)

(*d*) **A suitable guard** should be provided for the gage glass. (See Page 89.)

Blow-Off Piping

(*a*) Main blow-off line should discharge into a covered sump having vapor pipe and connection to sewer. The arrangement should be such that end of blow-off pipe in sump can be readily inspected.

(*b*) Where valves with slotted bolt-holes are used, a band or clamp should be placed around the flanges to prevent bolts working loose and dropping out.

Feed Water Supply

(*a*) Where it is at all possible, there should be two independent sources of feed water supply for the boilers. In many plants this is possible by connecting up with a city water line, or by connecting to the regular service of the works when the heater is ordinarily supplied by an independent pump with hot well water.

Feed Water Regulators

(*a*) The use of feed water regulators (preferably in conjunction with high and low water alarms) is suggested wherever they will be of advantage or assistance to the water tender in maintaining the water level in boilers. In some boiler plants having but one water tender, the boilers are located in two rows facing each other, sometimes with a coal pile between; in other plants the boilers are in a long row; in other plants the water columns are on two different levels, etc. Under such conditions the regulations of the water level is sometimes partly attended to by the firemen, especially if the water tender has his attention temporarily taken up in correcting some trouble that exists.

(*b*) Under any of the above conditions, or in similar conditions which may occur in various combinations, the use of feed water regulators is recommended. Their use is not suggested for the purpose of fuel economy, or to effect labor saving by dispensing with water tenders, but only for the purpose of supplementing the work of the water tender, to relieve him of the detail of valve manipulation, thus enabling him to give closer supervision to the maintenance of the proper water level in all boilers.

(*c*) Wherever water regulators are used, they should be accompanied by the use of governors on the boiler feed pumps, — the "Constant Excess Governor" being preferred.

Damper Regulators

(*a*) Where damper regulators and non-return valves are both used, great care must be exercised in locating the steam connection of the regulator to the main steam system. If this steam connection is made in the main steam system, and a break occurs in this system, the steam pressure will fall, closing the non-return valves and also opening the damper regulator, thus putting full draft on boilers with the main valves closed. To avoid this, the connection for the damper regulators should be made to several

Fig. 1. Swivel Gage-Glass Guard.*

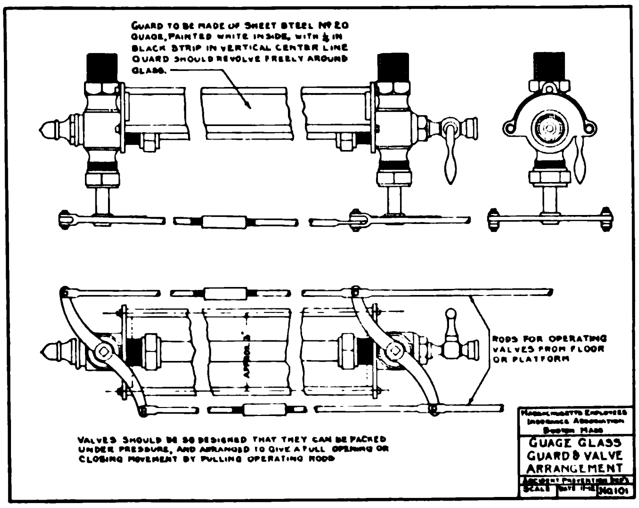


Fig. 2. Drawing of Swivel Guard.*

Fig. 3. Wired-Glass Gage-Glass Guard.

The gage-glass guard shown in Figs. 1 and 2 is ordinarily kept back of the glass (Fig. 1), where it serves as a reflector. It can be revolved to the front, however, for the protection of a man turning steam into a new glass, or working in a position where he might be injured if the glass should burst. It is recommended where the gage-glass is high (say 10′ or more above the floor), and intermittent protection only is needed.

Fig. 4. Section through Wired-Glass Guard.

For locomotive cranes, steam shovels, stationary boilers, etc., where the glass is low (less than 10′ above the floor), and constant protection is needed, the type of guard shown in Figs. 3 and 4 is preferable. This guard can be kept in position between the workmen's eyes and the glass, without interfering with the view of the water-level.

Fig. 5. Erosion or Corrosion of Gage-Glass in Service.

Fig 5. illustrates conditions that may cause a glass to burst at any time.

Fig. 6. Particles of bursting Gage-Glass caught by Wired-Glass Guard.

Fig. 6. gives a graphic impression of the eye hazard to persons near a bursting gage-glass. Particles are thrown in every direction, like a charge of bird-shot.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

boilers, between the non-return valve and the boiler.

Numbering Boilers

(*a*) Each boiler should be fitted with at least three number plates (each having the same number) as follows:

(*b*) One on the front of the boiler; one on the rear of the boiler; one on the pipe system between the boiler steam nozzle and the header, in such a position that it can be readily seen from the walk or platform over the top of the boiler setting.

(*c*) The two number plates placed on the boiler proper should be preferably of enameled steel, with white letters on a blue background. For marking the valves, however, heavy sheet metal plates with perforated numbers are recommended, so that the valves could be readily distinguished by touch in case of emergency, such as lights going out, etc.

Locks for Furnace Doors, etc.

Six men who were standing (or passing) in front of a boiler were injured by the blowing out of a single boiler tube, in a Massachusetts plant in December, 1912. These injuries would probably have been prevented, or their seriousness greatly reduced, by the use of furnace doors which swing inward as shown in Fig. 2, Page 79.

When the construction does not permit of this arrangement, the doors should be provided with positive latches (see Fig. 5, Page 72) which will hold them shut except when in actual use. (Such latches preferably should be arranged so they can be operated with a shovel). The in-swinging door is preferred, however, because a rush of steam would probably close it automatically, whereas a latched door may be open, and, therefore, of no value, at the time when an accident occurs.

Boiler fronts should be securely bolted to the settings, in such a way that they cannot become loose, or fall when the brickwork is removed.*

For gas-fired boilers there should be one or more explosion doors communicating with the last pass, fitted into the wall of the setting. The seats of these doors should be set at such an angle as will insure gravity closure of the doors, while at the same time they are free to open in case of excessive pressure developing in the setting.

Economizers.

(*a*) Each economizer should be equipped with one or more safety valves, set so as to protect the economizer from over-pressure. For economizers of three hundred tubes or less, one 3" safety valve is recommended; for larger economizers two 3" safety valves, one at each end of the economizer. Safety valves should have substantial external levers for lifting the disc from its seat.

(*b*) Each economizer should be equipped with one or more explosion doors of gravity closing type, as mentioned above for gas-fired boilers. These doors should be located in the upper part of the side wall or top of the economizer chamber.

Stokers, Coal and Ash Handling Machinery, etc.

(*a*) All belting, gearing, couplings, shafting, set screws, keys, bolts, etc., for stokers, coal and ash handling machinery, or other auxiliary equipment, should be protected in accordance with general mechanical standards. (See Chapter 17.)

(*b*) Where there are ash tunnels underneath boiler plants, at least two stairways or other means of exit should be provided, arranged so as to eliminate any danger of men being unable to escape in case of an accident to the boilers which would allow steam and hot water to flow into the tunnel. "Dead ends" should be avoided.

(*c*) Provision should also be made for ventilating such tunnels, so that men can work in them safely and without discomfort.

(*d*) Attention is directed to the danger of persons being caught and suffocated by fine coal in bins, hoppers, etc. (See Fig. 2, P. 85, and Fig. 1, P. 267.) The arrangements should preferably be such as to render it needless for any one to work on the coal pile proper, suitable walks being provided from which the necessary trimming, etc., can be done with safety.

* In one instance of which the author has knowledge, a workman was fatally injured by an unsecured boiler front falling, while repairs were under way.

If, in case of emergency, work directly upon the coal pile is required, safety belts and ropes should be provided, and more than one person should always be present while such work is being done.

(*e*) Open flames should not be permitted in coal crushers or other locations where there are accumulations of coal dust. Electrical equipment in such locations should have wiring enclosed in conduit, with soldered joints. Motors, switches, lights and other apparatus should be of enclosed type, so as to avoid danger of igniting the coal dust and causing an explosion or fire. (See Fig. 1, P. 115.)

SAFETY RULES FOR BOILER OPERATION

Inspection. Boilers (and economizers) should be thoroughly inspected by a competent inspector, internally and externally, at least once per year. (This is in addition to the ordinary supervision of the plant as outlined below, and should be done by some one not immediately connected with the plant.) The Massachusetts Boiler Rules require annual external inspections of boilers about six months after the annual internal inspection. The boiler insurance companies usually make inspections approximately once in three months.

The Care of Safety Valves

(*a*) All safety valves on boilers in regular service should be tried at least once every twenty-four hours, by easing them gently from their seats. This practice should be followed regularly to insure the valve always being free to operate.

(*b*) The springs of safety valves become gradually weaker with use. In order to make a weakened spring continue to resist the pressure, its compression must be increased, which reduces the pitch of the spring and the lift of the valve. Therefore, a record should be kept of the valve lift at its rated capacity, and all valves should be gone over at least once per year to make sure that approximately the original lift is still obtained.

Water Columns and Try-Cocks

(*a*) Water columns should be blown out perfectly at least twice every twelve hours. If a gage glass is fouled internally so that the water level is not clear, the glass should be cleaned or replaced as soon as possible. If the fouling of the gage glasses occurs frequently, it is due to some characteristic of the water such as suspended matter, scale solvents, lubricating oils, etc., for which a remedy should be found. A gage glass is of little value unless the water level can be seen clearly and at some distance from the boiler.

(*b*) High and low water alarm whistle must be always kept in good working order.

(*c*) When "warming up" a new gage glass, or doing any work in such a location that a breaking glass might cause injury, the gage glass guard (if of swivel type) should always be turned so it will afford protection, being returned to its former position as soon as the work has been completed.

(*d*) The water level should be verified by means of the try-cocks immediately upon entering the boiler room at the beginning of the turn, also several times during the day. It is important that these cocks be kept in good condition, and their regular use is necessary to insure this being done.

Steam Gages

All steam gages should be kept in proper operating condition, so that the pressure indicated will be approximately correct. They should be tested with an accurate steam gage or with a weight testing machine, at sufficiently frequent intervals to insure a reasonable degree of accuracy being maintained. (The Massachusetts Rules require a $\frac{1}{4}''$ pipe connection for attaching inspector's test gage when boiler is in service.) When boilers are being inspected, care should be taken to make sure that the connections to steam gages are clear.

Stop Valve Stems

(*a*) Rising stems of valves should not be permitted to become rusty or covered with dirt so that they cannot be readily moved to the full extent of their travel. A periodic inspection of all valves, stems, etc., in all the main piping systems about the boiler house should be made at least once a month. Too much importance cannot be attached to keeping the valves in such condition that they are always ready for use.

(*b*) Great care should be exercised in using a wrench or bar in opening or closing a valve. The abuse of this means of facilitating the handling of valves may result in damage to seats, threads, stems, etc., and under some circumstances may bring about dangerous conditions.

Leaks in Steam Pipe Systems and Other Parts Under Pressure

(*a*) If for any reason, such as blowing out of gaskets, vibration, overstraining of pipes, or general deterioration, the joints of steam pipes develop objectionable leaks, the application of wrenches to bolts of such joints while under steam pressure should be absolutely prohibited. If the joints are to be repaired, it should be done after the pressure has been removed from the particular section where the trouble occurs, by closing the proper valves. This precaution should be observed particularly with reference to bolts holding the tube caps of boilers.

(*b*) The person in charge of a boiler plant should open the doors and examine each boiler carefully for leaks, cracks, blisters, etc., at least once per day. Any such defect should be immediately reported, as it may indicate a dangerous condition.

(*c*) If the tubes of a fire tube boiler develop leaks at the tube sheet, expanders should not be applied to the ends of the tubes while the boiler is under steam pressure.

(*d*) If a leak develops at any part of the sections of a boiler, whether in the cast steel headers to which the tubes are attached, or at a riveted joint, the use of a calking tool to stop this leak while the structure is under steam pressure should be prohibited. This applies to rivets as well as plates, and all such repairs should be made after the steam pressure has been taken off the boiler.

(*e*) If a leak develops at a hand-hole plate or around the tube caps of water tube boilers, same should not be stopped by tightening up the bolts while steam pressure is on the boiler.

(*f*) If a leak develops at a manhole cover, it should not be repaired while the boiler is under steam, by tightening the bolts in the yoke.

Opening Steam Piping, or Turning Steam into Empty Pipe Sections

(*a*) Before breaking any steam pipe joints to make repairs, renew gaskets, etc., the dead section should be well drained — to avoid danger of scalding by steam or water remaining in the pipe.

(*b*) Steam should always be admitted to empty piping *very* slowly.

(*c*) If a portion of piping has remained unused for an hour or more, it is important that a complete drainage of such idle pipe system has been secured, previous to turning steam into it. This precaution should be in addition to that ordinarily provided by the use of steam separators, which are usually located near the engines.

Starting Fires in a Cold Boiler Setting

If a boiler has been out of use for a time sufficient to permit all parts of the setting to become cold, or if it is a new boiler just being put into service (in either case the boiler being one of a battery, a part of which is in service), the following method of procedure is advised, assuming that the equipment is complete as outlined.

(*a*) Make sure that all workmen are out of the boiler and setting, and that all manhole covers or other parts are properly in place.

(*b*) See that the stop valve between the "goose-neck" and header is tight, and that the drain pipes in the goose-neck are open; also that the drain valve underneath the non-return valve — if such is in use — is open, and that the connection to the steam gage is open and in good condition.

(*c*) Open the feed valve and fill the boiler gradually, until the water level stands between the first and second gages of the water column.

(*d*) Start a very light wood fire in the furnace and have the stack damper practically closed. The escape of smoke, under such conditions, from the setting, will indicate any air leaks, unclosed doors, or other defects which are undesirable when a boiler is in service. If any such leaks are observed they should be corrected before proceeding further. (In case of a new boiler, or a boiler with new brick-work in the furnace, this preliminary heating should be continued for a day or two if possible before anything more is done.)

(*e*) Continue the firing, with gradual addition of coal (the damper being adjusted to the requirements), until all air is driven from the boiler and steam is escaping from the drain pipe of the water column, or from any other small pipe connection in the boiler which is open.

(*f*) In a period of at least two hours the steam pressure in the boiler should be brought up practically to that of the pressure in header (though, as stated above, if the boilers are new, a much longer time should be taken).

(*g*) While steam pressure is rising in the boiler, the gate valve between the boiler and the steam main should be slowly opened. This leaves the boiler still shut off from the main by the non-return valve. When the pressure on the boiler has risen to the required pressure, the non-return valve will open, automatically placing the boiler in connection with the main steam system.

(*h*) Before commencing heavy firing, corresponding to the service in the remainder of the battery, lift the lever on the safety valve to see that it is free to act and observe at the earliest opportunity whether this valve lifts at the allowed pressure of the boiler, or under that pressure.

(*i*) At this time the stop valve in the feed water pipe near the feed main of the boiler-house should be wide open, also the stop valve between the check valve and the boiler; the feed controlling valve should be adjusted by the water tender to an opening such as will provide the required water delivery.

Checking Fires

(*a*) The practice of checking fires by opening fire doors, so as to permit an inrush of great quantities of cold air into the boiler setting and stack, is bad from an economy standpoint, and is attended by more or less danger, due to the rapid change of temperature of the boiler and setting structure.

(*b*) As an alternative to this, it is strongly advised that so far as is at all possible, fires should be checked by means of the dampers, thus interrupting the flow of hot gases from the boiler setting.

(*c*) In case of low water the fires should be covered with wet ashes (or fresh coal), and subsequently drawn. Feed water should not be turned in until the boiler has been cooled off and carefully examined for damage.

Blowing out Boilers

(*a*) The bottom blow-off in boilers should be used at least once every 12 hours, the valves in the blow-off connections being left open for a period of from one-half to one and a half minutes, in accordance with the character of the feed water supply. If the water is badly contaminated by scale forming material, the longer period for blow-off is recommended. If feed water which has been treated in water purifying plants is used, it may be advisable to blow off a longer time and more frequently. A feed water supply consisting of the hot well discharge from surface condensers, or exceptionally good natural water, may permit of shorter periods for blow-off and less frequently, but such favorable conditions are not the rule.

(*b*) Blow-off cocks should be opened slowly, so as to avoid "water-hammer" which may burst the piping or connections.

(*c*) When a boiler is to be emptied, this should not be done until the setting has cooled.

Laying off Boilers

When a boiler is to be taken out of service for cleaning, etc., the following procedure should be observed: —

(*a*) Check the dampers and allow the fires to burn out, at which time the non-return valve will be seated; also close the gate valve in the branch next to the header, and open the drains in the "goose-neck."

(*b*) Shut off the stop valves in the feed system.

(*c*) Open the dampers wide and allow the steam pressure to fall, as a result of the heat absorbed by the air passing through the setting and boiler into the stack.

(*d*) After the boiler is cooled, the blow-off valves may be opened and the water allowed to flow out of the boiler.

Cleaning Boilers

(*a*) Preparatory to cleaning or inspecting a boiler, and as soon as it has been taken off the line, the following precautions should be observed: —

1. Lock the stop valve in the "goose-neck" next to the header, so that it cannot be moved except by the man in charge of subsequent operations. He should keep this key in his possession, as well as the keys for the other locks mentioned in the succeeding paragraphs.

2. The blow-off valves should be closed and one of them locked in position, in such a way that it is impossible to open this valve, except by using the key.

3. Similarly, lock the stop valve in the feed pipe next to the feed header.

4. Place on the stop valve handle, on the blow-off valve, and on the feed stop valve, a durable and legible sign, with the following wording — "MAN INSIDE, DO NOT TOUCH." (This sign may be painted on the enclosing cover, described in a succeeding paragraph. The locks should be left in place on valves until boiler is ready to be put into service again.)

(*b*) Open escape pipe on steam nozzle, or water column drain pipe valve, so as to make sure that there is no pressure remaining in the boiler; manhole covers may be then taken off and the boiler opened up for cleaning. It should be an invariable rule that the man who enters a boiler for the purpose of cleaning or inspection, should be in possession of the keys controlling the above mentioned locks, and he must give the final assent for the return of the manhole covers to their places.

(*c*) Previous to entering a boiler, it is advisable to determine whether there is any gas or bad air present, by passing a torch or candle inside. No one should be permitted to enter a boiler with an open light if kerosene has been introduced into the boiler after it was emptied.

(*d*) For locking the valves, the following method is recommended: Make a loose cover for the hand-wheel of the valve out of sheet steel. This cover is simply a circular box made in halves and hinged at one side, with a hole in the bottom for the valve stem. On the side opposite the hinge, an arrangement is made for attaching the lock, so that the box can be locked shut. This box should be painted bright red, with white lettering. For large steam valves, the box may also have a sleeve extension to cover the valve stem, thus preventing the use of a wrench on the stem of the valve. (See Fig. 3, P. 79.)

Cleaning Boiler Settings

(*a*) Cleaning the setting of a coal fired boiler should not be commenced until the walls of the setting, and any material inside it, such as flue dust, etc., have been reduced to such a temperature that there is no possibility of a man being burned by coming in contact with them.

(*b*) Dampers and doors should be left open while men are inside setting, so as to maintain a circulation of air through the stack.

(*c*) Electric lights should be used, wherever possible, in preference to open lights or torches.

(*d*) The cleaning of gas fired boilers will necessitate an additional precaution in the way of testing the chambers by means of lighted candle or torch, to detect the presence of gas or bad air before a man goes inside.

(*e*) The gas valve leading to a gas fired boiler should be absolutely blocked against manipulation, and protected from any tampering by a suitable sign which will serve as a warning that work is going on in the boiler setting.

Economizers

(*a*) When placing an economizer in service the outlet damper should first be opened and then the inlet damper opened, slowly. In taking an economizer out of service, the inlet damper should first be closed; when the machine has cooled sufficiently the outlet damper may be closed; the explosion door (or doors) should then be opened and allowed to remain open during entire time economizer is out of service.

CHAPTER 12

ENGINE EQUIPMENT

STEAM ENGINES

THE greatest accident possibility in connection with engine equipment is that of bursting fly-wheels. This constitutes a serious catastrophe hazard in engine driven plants which has resulted in many bad wrecks. (See Page 97.)

Accidents which are more frequent but usually of a less serious nature, occur from the blowing out of cylinder heads. There are also the common mechanical hazards of rapidly moving parts, crushing and shearing actions, etc., and danger from escaping steam in case some part of the piping or steam cylinder should give way.

Fly-wheel construction

Fly-wheel explosions are usually caused by over-speed, by some stoppage or obstruction of the engine parts, or by a sudden and extreme variation of the load, such as might be occasioned by a main belt or shaft breaking.

Since a fly-wheel accident is usually so destructive in character, every precaution should be taken to avoid it. The wheel should be so designed as to use the material to best advantage and great care should be taken to secure the highest possible degree of uniformity in its construction, as on this its stability largely depends.

The principal stresses in a fly-wheel are those resulting from centrifugal force. The arms are placed in tension by this force, and they are also called upon to transmit power from the shaft to the rim, and vice versa.

The bending stresses thus normally produced in the arms are increased by variations in the load which result from the starting and stopping of the machinery driven. They may also be augmented to an unusual degree by a stoppage or obstruction of some sort, such as would result from water being caught in the engine cylinder.

It is accordingly important to use a rugged design with a high factor of safety (say 10) for the arms, particularly when the load is subject to rapid fluctuations as in rolling mill work or electric engines supplying power for travelling cranes, street cars, etc.

Formulas for designing fly-wheel arms may be obtained from the various engineering handbooks. The principal point of interest to the safety inspector in this connection, however, is that of the stresses produced in the rim of the fly-wheel by centrifugal force.

Material

Other things being equal, the material which has the highest tensile strength per unit of weight is best suited for the construction of fly-wheels. This may be demonstrated as follows:

Taking the familiar formula for centrifugal force $f = W\frac{v^2}{Rg}$ in which

$f =$ centrifugal force in pounds
$W =$ Weight of body in pounds
$v =$ velocity of body in ft. per sec.
$R =$ radius of path of centre of gravity of body in feet.
$g =$ acceleration of gravity, say 32.16.

The tensile stresses in the rim tending to separate it into halves are less than the total value of f (designated by F) in the proportion of the circumference to the diameter of the wheel. Since these stresses are equally divided between the two sides of the rim, the value of the tension in the rim $= \frac{F}{2\pi}$ or $\frac{F}{6.2832}$.

The unit stress $= \frac{\text{tension in rim}}{\text{area, A, of cross-section of rim in square inches.}} =$

$\frac{F}{6.2832A} = \frac{\text{Wt. of rim, W,} \times v^2}{6.2832A\ Rg}$. Dividing by A

Wt. of 1 cu. in. × circumference

we get

$$\frac{\text{C, in inches} \times v^{2*}}{6.2832\ Rg}.$$

Since circumference C, in inches = C in ft. × 12, and 6.2832 R = C in feet, these items cancel, leaving unit stress $s = \frac{\text{Wt. 1 cu. in.} \times 12 \times v^2}{g \text{ or } 32.16}$.

Representing wt. of cu. in. by w, $s = \frac{w\,v^2}{2.68}$, $v = \sqrt{\frac{s \times 2.68}{w}}$ or $1.637\sqrt{\frac{s}{w}}$. Substituting for unit stress s, the tensile strength of the material per square inch, T, we have $V = 1.637\sqrt{\frac{T}{w}} =$ the velocity in feet per second at which failure will result from centrifugal force. In other words, the safe velocity is determined by the ratio of $\sqrt{\frac{T}{w}}$.

If % = efficiency of joint, and F.S. = factor of safety, — V, or safe speed in feet per second $= 1.637\sqrt{\frac{T}{w} \times \frac{\%}{F.S.}}$.

Safe speed in feet per minute =

$$98.22\sqrt{\frac{T}{w} \times \frac{\%}{F.S.}}.$$

By this formula the safe rim-speed of any fly-wheel can be determined, irrespective of the material of which it is constructed.†

It is apparent that $\frac{T}{w}$, or the ratio of tensile strength to unit weight, is an important factor in selecting the material for fly-wheel construction. Judged by this standard, the good grades of wood should rank highly as a material for building fly-wheels.

As a matter of fact a number of wooden wheels have been constructed. They are relatively expensive, however, and in order to cut the material in a form which will develop its strength lengthwise of the grain, at the same time conforming to the curve of the wheel, many joints are necessary. It is difficult to estimate the strength of these joints accurately, and they are likely to be weakened by the checking or cracking of the wood as time goes on. It is accordingly improbable that wooden fly-wheels will ever be used to any considerable extent.

Steel is a desirable material for this service, and fly-wheels constructed of laminated steel plate are coming into more general use. They are particularly advantageous where high peripheral speeds are necessary, or where there are rapid fluctuations in the load. (See Fig. 2, P. 99.) They are also relatively expensive, however, and for ordinary service cast iron is most commonly used on account of its low cost and simplicity in construction.

There are two principal sources of difficulty in connection with cast-iron wheels. If they are cast solid, unequal shrinkage is almost certain to occur as the metal cools, resulting in dangerous stresses which may cause the wheel to fail under normal service conditions, or under some slight overload which it would otherwise withstand satisfactorily. Shrinkage strains are particularly liable to result in cracks developing at the point where the arms join the rim of the wheel.

If, on the other hand, the wheel is built up in sections, as is necessary in large wheels, there is difficulty in getting a satisfactory joint and the factor of safety of the wheel is reduced in direct proportion to the efficiency of the joint.

Efficiency of Joints. (See Fig. 1, P. 99.)

It is difficult to make an accurate determination of the strength of a joint in the rim of a fly-wheel by theoretical means. Some valuable data on this subject has been contributed by Prof. Benjamin, however, as a result of actual bursting tests conducted by him at the Case School of Applied Science in 1898 and 1899.‡

* This is not absolutely accurate, since the cross-sectional area times the circumference does not give the exact cubical contents. The error is slight, however, and may be disregarded for large wheels.

† There are also bending stresses produced in the rim, which affect the result somewhat, particularly for thin-rimmed wheels. This formula gives satisfactory results however, when used with an ample factor of safety.

‡ See Transactions of the American Society of Mechanical Engineers, Volume 20, Pages 209–243, also Volume 23, Pages 168–185.

Fig. 1. Wreck caused by Bursting Fly-Wheel.

Fig. 2. Results of Fly-Wheel Explosion.

Fig. 3. Dangerous Exhaust Pipe.*

Figs. 1 and 2 give a graphic impression of the result of bursting fly-wheels. This indicates the necessity for precautions against over-speeding or other conditions which may cause a wheel to burst.

Fig. 3 shows an exhaust pipe located where persons may be scalded by the sudden discharge of steam from it.

All such pipes, unless so located that there is no danger of persons passing in front of them, should discharge into covered exhaust pits, provided with suitable drainage and ventilating facilities. They should not be allowed to discharge within 7′ of the ground, floor, or platform level, where some one might be injured by the escaping steam.

* Courtesy of United Gas Improvement Company.

An abstract of the results of these tests, for characteristic wheels, is given in the following table.

Wheel No.	*Dia. Inches*	*Breadth × Depth of Rim*	*Bursting speed, velocity in ft. per min.*	*Centrif. tens.* $=\frac{v^2}{10}$	*Remarks*
Solid Wheels, no joint.					
1	15 1/8	2 × .70	25,800	18,500	
2	15 1/8	2 × .65	25,800	18,500	
3	15	2 × .615	23,700	15,600	Thin rim
4	14 13/16	2 × .52	22,800	14,400	" "
9	14 5/8	1 7/8 × .40	21,900	13,300	" "
10	14 1/2	1 7/8 × .347	21,660	13,000	" "
11	24	2 1/8 × 1.5	23,100	14,800	
Split Wheels, Two Flange Joints, midway between arms, bolted.					
5	15 9/32		11,520	3,700	
13	24	4 × .75	11,040	3,400	Flange broke
14	24	4 × .75	11,760	3,850	Bolts "
15	24	4 1/16 × .75	11,400	3,610	Flange "
Split Wheels, Two Flange Joints, 1/4 dist. between arms, bolted.					
3a	24	4 × .84	11,310	3,570	
4a	24	4 × .84	11,616	3,750	
5a	24	4 × .84	11,940	3,950	
6a	24	4 × .84	11,616	3,750	
Sectional Wheels, Six Pad Joints, opposite arms, bolted.					
15a	24	4.10 × .56	13,080	4,800	
16a	24	4.00 × .57	13,680	5,200	
Split Wheels, Two Link Joints, oval links shrunk on lugs midway between arms.					
16	24	1.2 × 2.1	19,200	10,240	3 lugs & links
17	24	1.2 × 2.1	17,400	8,410	2 " "
Sectional Wheels, Eight Joints, I-links, shrunk in midway between arms.					
7a	24	2.22 × 2.23	15,390	6,600	Two links per joint.

The wheels recorded above were tested in two lots in successive years, the second lot being designated by "a." All of those recorded above had six arms, except No. 7a, which had 8. Test pieces of the iron used in some of the wheels showed 19,000 lbs. tensile strength.

The wheels tested were mostly models of large fly-wheels, designed by reputable builders. While it is possible to get greater uniformity in a small casting of this character than in a large one, the results show, with considerable accuracy, the relative value of different types of joints.

The solid rim of proper thickness developed approximately the full tensile strength of the metal, before it gave way. Its factor of safety would be 1.

Making the rim thinner caused it to fail sooner on account of inability to resist the bending stresses which develop between the arms. Some wheels made with three arms instead of six failed at about the same speed as the thin-rimmed wheels.

Split wheels, with flange joints located midway between the spokes were the weakest of all, and developed only 20 to 25 per cent of the strength of the solid rim. This indicates a most inefficient type of design, and is equivalent to putting a joint in the middle of a heavily loaded beam. The extra weight of the flanges and bolts composing the joint adds materially to the stresses, at a point least suited to resist them.

Changing the joint to the normally neutral point $\frac{1}{4}$ of the distance from one arm to the next, did not materially alter the results.

Placing the joint opposite the end of the spokes caused considerable improvement, these joints showing an efficiency of about 35%.

The split wheel with joints formed by three oval links shrunk on to lugs gave the best results, with an efficiency of about 60%. The use of only two links weakened the joint considerably, and the I-type of link showed only about 45% efficiency.

Factor of Safety

Fly-wheels over 8 ft. in diameter are usually cast in halves, or in sections of various types.

As it is impossible to get absolute uniformity in a large casting of this kind, a high factor of safety should be used, and a conservative value should be placed on the strength of cast iron. Assuming this at 10,000 lbs. per square inch, a solid cast-iron fly-wheel has a theoretical factor of safety of about ten, when running at a peripheral speed of 6,000 feet per minute.

Since this factor is reduced by the joint as already indicated, it is generally considered desirable to run a large fly-wheel at a somewhat lower speed, and common practice has settled on about 5,000 feet, or "a mile-a-minute." With the inefficient flange joint midway between arms this speed would still be too great,

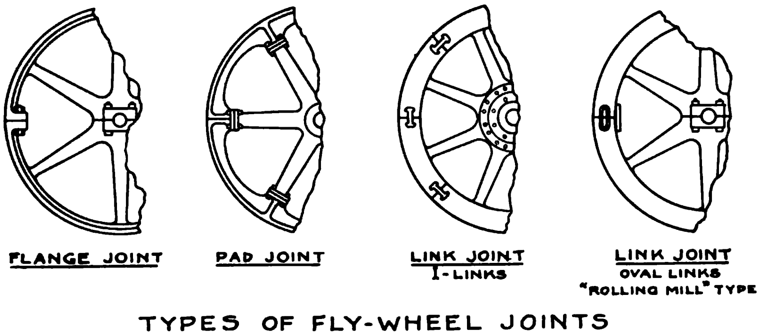


Fig. 1. Drawing showing Common Types of Fly-Wheel Joints.

Fig. 2. Laminated Steel Fly-Wheel, 24′ Diameter.*

Fig. 1 shows various types of fly-wheel joints. Actual breaking tests indicate approximately the following relative strength for these joints: — Solid wheels, — 100; flange joint, — 20 to 25; pad joint, — about 35; link joint, two I-links, — about 45; link joint, three oval links shrunk on to lugs, — about 60.

Fig. 2 shows a type of fly-wheel that may be used for high speeds, or where there are extreme variations in the engine load.

Fig. 3. Guards for Shear-Points in Hooks of Corliss Valve Gear.

Fig. 4. Hooks of Corliss Valve Gear with Guards removed.†

Fig. 5. Engineer injured by Corliss Valve Gear.

A shear-point, where fingers may be caught and crushed, is formed by the hooks of the familiar Corliss type of valve gear. Accidents have occurred at these points, usually due to the engineer attempting to clean or wipe the equipment while it is in motion, or to some slip or mis-move on his part. The engineer shown in Fig. 5 had his hand caught while attempting to recover an oil-can knocked from his grasp by the moving gear.

A simple and effective guard for these shear-points is shown in Figs. 3 and 4. This consists of metal plates fastened by screws to the disconnecting-links.

Note guard at crosshead, and automatic engine stop connected by sprocket to stem of throttle valve shown in Figs. 3 and 4.

* Courtesy of Boston Elevated Railway Company.
† Courtesy of American Steel and Wire Company, subsidiary United States Steel Corporation.

since it would reduce the factor of safety to 3.7

It should be remembered that, since the stresses increase as the *square* of the speed, the factor of safety as regards speed is the *square root* of that of materials. In other words, the factor of safety of 3.7 mentioned above would indicate that the wheel might fail before the speed was doubled. Adding material in the rim does not appreciably increase the strength of a properly designed wheel, on account of the fixed ratio of $\frac{T}{W}$ already referred to.

From this it will be apparent how important it is to positively limit the speed of a fly-wheel, and to take every reasonable precaution to make certain that the engine will not be permitted to race.

Governing Arrangements

There are several ways in which an engine governor may become deranged and fail to control the engine speed properly. In the case of the common fly-ball type of governor the driving gears or shaft may break, the key may work out of the driving pulley, the driving belt may slip, or the governor may "stick."

The arrangement is commonly such that any one of these occurrences will cause the engine to race, unless some special provision is made to guard against it.

All Corliss valve gears should be equipped with a "Low Plane Governor Stop." With this arrangement, whenever the governor ceases to revolve, the governor weight drops to its lowest position and the trip collar is rotated to a point where a safety cam on the collar comes in contact with the disengaging link, thus throwing it into a position where it does not hook up. (See Fig. 1.) This stops the admission of steam to the cylinder and quickly shuts down the engine.

With the governor weight in its lowest position it is impossible to start the engine again, since the hooks cannot pick up. It is accordingly necessary to raise the governor weight and support it on a pin or bracket at such a height as will free the disengaging link from the safety cam and permit the hooks to engage once more and admit steam to the cylinder. (See Figs. 2 and 3, P. 105.)

These brackets may be arranged so they can be placed underneath the governor weight before the engine is shut down, thus avoiding the

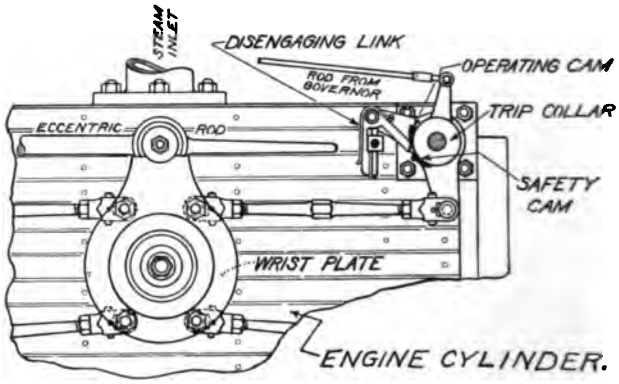


Fig. 1.

inconvenience of lifting the weight and inserting the bracket each time before the engine can be started up. The bracket should always be counterweighted however, or otherwise arranged so that it will drop out of position automatically when the engine starts. It should never be designed so that the engineer is required to throw it out of position by hand each time after the engine is started, to bring the safety stop into play, since the slight oversight of neglecting to do this might result in wrecking the engine.

Where the load is variable, the engine may slow down under a heavy load so that this safety stop comes into play and shuts down the engine; to prevent this, an engineer will sometimes place a positive stop under the governor weight, thus putting the safety device out of commission. This should never be permitted. The difficulty can be readily overcome by installing the device shown in Fig. 1, P. 105.

Governor Belts

A belt inevitably wears out and breaks sooner or later, and the failure is likely to occur without warning. The breaking of governor belts has been responsible for many engine accidents, and some arrangement is needed to minimize the danger from this source.

In an effort to overcome the difficulty, some engine builders have installed an idle pulley which runs on the governor belt. This pulley is connected by a swinging arm to the bracket underneath the governor weight, the idea being that if the governor belt should break the bracket would be thrown out, permitting the weight to drop and stop the engine.

This arrangement, instead of being a satisfactory one, introduces an entirely new element of hazard, and is of no real value since the same object can be accomplished safely by other means.

In using this device the fact is lost sight of that governor failure may occur from several causes other than breaking governor belts, in any one of which the so-called "safety device" on the governor belt holds the bracket underneath the governor weight, throwing the valves wide open and causing the engine to race.

The governor gears are usually enclosed, so that if they once start to chip, broken particles get into the gear teeth and the gears are almost certain to be stripped.

The author has personal knowledge of a fly-wheel explosion from this cause, which involved an expenditure of approximately $20,000 for repairs, besides injuring the engineer and shutting down the plant for about two months. This accident could have been avoided by the use of the automatic counterweighted bracket, previously mentioned.

Where the idle pulley arrangement is already in place on a governor belt, it is desirable to disconnect it from the governor bracket, although the pulley may be left running in contact with the belt and serve as a tightener, thus reducing danger of the belt slipping.

A preferable arrangement, however, is to use a rope drive, of at least three strands, instead of a belt. With this arrangement a single rope is sufficient to drive the governor, so that the breaking of any one rope will not interfere with the governor action, and the ropes as they become worn can be replaced one at a time.

A rope drive practically eliminates the danger of slipping. A governor belt is likely to become oily, in which condition it may slip and permit excessive speed while conditions are otherwise normal.

Auxiliary Controlling Devices

Where engines are equipped with valves of other than Corliss type, the low plane governor stop cannot be applied. Neither is it applicable to engines having shaft governors, although the danger of a runaway with a shaft governor is somewhat less than where the ordinary fly-ball governor is concerned, since there is more likelihood of any derangement in a shaft governor shutting down the engine instead of causing it to race.

In all such cases it is recommended that an auxiliary governing device such as the "Speed Limit" of the Automatic Engine Stop (see "Power Control," Chapter 14) be installed. This is desirable even where the Low Plane Governor Stop is found, since it affords an additional element of protection.

A butterfly or other quick-closing valve in the main steam line is of some value in case the engine starts to race, since by it the engineer can shut off the steam supply more quickly than by closing the regular throttle valve. A butterfly valve is not steam-tight however, and cannot be depended upon for entirely stopping the engine.

Valves of this kind are inferior to the automatic Speed Limit in another important respect, since they are dependent on the presence and alertness of the engineer for their operation.

Water in Engine Cylinder

Serious engine accidents may be caused by water in the cylinder. This usually results in knocking out the cylinder head, under the impact of the moving piston, and it may also cause fracture of the fly-wheel or other parts.

The presence of water in the cylinder may be caused by failure to drain out the condensation properly before starting up the engine, by a "slug" of water being carried over from the boiler, or by water rising in the condenser where engines are of condensing type.

To prevent these hazards, care should be taken in laying out the steam-piping to eliminate water pockets and dead-ends in which water may accumulate. Where these cannot be avoided, drain-pipes should be installed, preferably connected to traps which automatically remove the water. In starting an engine it should be warmed up slowly, and extreme care should be taken to see that any water that has gathered in the cylinder or piping is thoroughly removed before the engine is actually started.

A separator of ample capacity should be located in the steam-pipe, as close as practicable to the engine cylinder, to take care of any excess moisture in the steam. This separator should be connected to a trap.

Steam traps should be so arranged that it will be known for certain that they operate. If it is necessary to locate these traps below the engine-room floor, or in places where they cannot be seen readily, an electric light, bell, or other suitable device, should be used, so the man in charge will know when the trap operates. Allowing traps to get out of order may permit accidents to occur.

To avoid danger of water from the condenser, an automatic vacuum breaker should be installed on engines provided with individual condensers. Vacuum breakers should be arranged to open when the water rises to a certain point in the receiver.

A live steam connection to a receiver should not be made without providing a reducing valve, set so that the pressure it permits will be well within the safe working pressure of the receiver and the low pressure cylinder.

When repairs or alterations are under way on blowing engines, pumping engines, air compressors or other types of large engines, the fly-wheel or crosshead should be securely blocked, if the nature of the work which is being done is such that persons might be injured by the engine taking a stroke, and if there is any chance of pressure building up in a steam (or air) cylinder until a movement of the piston results.

Various accidents have been reported from such occurrences. In one of these, three men were caught in the air cylinder of a blowing engine and crushed to death, the engine starting unexpectedly on account of a leaky valve.

Where there are large engines on which such an accident might occur, it is well to post a notice reading somewhat as follows:—

> NOTICE
>
> ALL PERSONS ARE FORBIDDEN TO ENTER AN ENGINE CYLINDER OR DO OTHER WORK WHERE THEY MIGHT BE INJURED BY THE ENGINE STARTING, UNTIL THE FLY-WHEEL OR CROSSHEAD HAS BEEN SECURELY BLOCKED.
>
> ______________
> *Supt.*

In taking the heads off of steam cylinders or valve chests of engines, pumps, compressors, etc., which have recently been in use, the indicator cocks should first be opened to make sure that there is no steam-pressure in the cylinder. In addition to this, the joints between the head and the flange should be broken before all the nuts on the cylinder bolts are completely unscrewed. This will prevent the head being blown off when the joint is broken, should any pressure exist in the cylinder.

Automatic relief valves should be installed in exhaust lines between engine and shut-off valve, where the arrangement is such that the exhaust line might be subjected to excessive pressure by an obstruction or the accidental closing of a valve.

Protection of Engine Fly-Wheels, Belt Wheels, etc.

All engine fly-wheels should be guarded so as to prevent injuries through accidental contact with them. The arrangement should be such, also, that objects on adjacent floors or platforms cannot roll into the fly-wheel pit; a serious accident may be caused by such an occurrence, due to the object being thrown out at high velocity by the revolving wheel. For the protection of fly-wheels, belt wheels, etc., the following standards are recommended:—

Fig. 1. Enclosure of Crank and Connecting-Rod.*

Fig. 2. Enclosure of Crosshead.*

Fig. 3. Guards for Crank, Crosshead, etc.*

These photographs illustrate model engine enclosures. Such enclosures are of value in protecting employees from accidental contact with moving parts, and in addition they effect a saving through the elimination of splashing and waste of oil. This reduces the fire hazard, as well as that of employees slipping on oily floors.

Thorough enclosure such as is shown in Figs. 1 and 2, is preferable where it can be adopted, as it keeps the oil clean and free from dust.

The enclosure shown in Fig. 3 is less complete, but affords adequate protection for employees, at the same time allowing free ventilation where there is danger of bearings running hot. These guards are made of 16-gage planished steel plate finished with brass rivets, thus giving a neat, workmanlike effect.

Railed stairways are provided at the main bearing and along the bed of the engine, for the safety of the oiler. (See Fig. 3.)

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fly-wheels and pulleys shall be provided with a standard railing (or solid enclosure) at least $3\frac{1}{2}$ feet high. (See Fig. 1, P. 105.) If the fly-wheel extends into a pit, a toe-board at least 6″ in height shall be provided along any exposed edges of pit.

Where railings are used for such guards, they shall be covered with wire fabric, sheet metal or other suitable material, at all points where an arm (assumed to be 2′ in length) projected through the railing might be injured by the revolving wheel.

Clearance between wheel and exposed edge of guard shall be not less than 3″, for any guard less than 5′ in height.

For rope sheaves the protection shall be either solid, or, if a railing, filled in with wire mesh, sheet metal or other material so as to leave no exposed parts around which a breaking rope might wrap.

Wheels extending less than $3\frac{1}{2}$′ above the floor may be entirely encased, if desired. (See Fig. 2, P. 165.)

(For automatic engine stops and other forms of power control, see Chapter 14.)

Safety Specifications

The following safety specifications for large engines were embodied in a paper by the author, presented before the Engineers' Society of Western Pennsylvania in March, 1912. (See "Proceedings" for April, 1912.) In that connection indebtedness was acknowledged for information obtained through the medium of the Committee of Safety, the Board of Engineers, and the Steam Engineers' Committee of the United States Steel Corporation.

The use of some such specifications is advised whenever new equipment of this kind is being purchased, in order to make certain that important safety features will not be overlooked. Many of these provisions should also be made for engines already installed.

(1) Governor, if not shaft type, shall be driven with ropes (not less than three in number).

(2) Governor sheaves shall have suitable guards of substantial construction. (See Fig. 2, P. 105.) Sheaves to be keyed to shaft and unused portions of keyway filled so as to present a smooth surface.

(3) Corliss valve gear shall be equipped with safety cams which unhook the valves when governor weight drops to low position. A suitable bracket must be provided for supporting this weight when shutting down engine, so arranged that it will drop out automatically after the engine is started up. (Fig. 3, P. 105.)

(4) Where a fly-ball governor is used, the revolving parts shall have an approved guard or enclosure, so arranged as to prevent waste of oil. (See Fig. 2, P. 105.)

(5) All gearing shall be *completely enclosed* with substantial oil-tight covers of cast iron or steel plate, so designed as to be readily detachable.

(6) All couplings, set screws, keys, bolts, etc., in moving parts, must be countersunk or covered in such a way as to eliminate danger of accident.

(7) Where main bearings cannot readily be reached from the floor, they shall be equipped with steps properly railed; railings to have two parallel members, and an approved safety tread to be used for steps. (See Fig. 3, P. 72.)

(8) All platforms and walks on engine shall have railings and toe-boards (this applies to engine bed also where it is subject to use as a foot-walk along connecting rod). Toe-boards shall be at least 6″ high, railings not less than 3′–6″, with an intermediate member. Where pipe is used for railings, it shall be "extra heavy," and provided with special hand-rail fittings.

(9) There shall be an approved guard or enclosure at crank and connecting rod (also at tail rod, if engine is of this type); this enclosure to be of steel plate not less than No. 14 gauge in thickness, and arranged so as to prevent waste of lubricating oil, in addition to safeguarding employees. (See Page 103.)

(10) Each receiver shall be equipped with one or more safety relief valves of ample capacity, set to blow at a pressure well within safe working pressure of receiver and low pressure cylinder; receivers to be provided with gauges, so the pressure can be readily observed at all times.

(11) A relief valve must be placed in each end of each cylinder. These valves should have hand levers, or other adequate means for lifting valve from seat to test it.

(12) Care should be taken in the design of valve mechanism and other moving parts, to avoid places where a hand or foot might be caught and crushed; where such places necessarily occur, they must be properly safeguarded. (See Figs. 3 and 4, P. 99.)

(13) These safety features shall be subject to the approval of the —— Company's inspectors, who shall be given an opportunity to inspect the engine at any time requested.

Fig. 1. Overload Device for Engine Governor.*

Fig. 2. Operating Device for Governor Bracket, etc.*

All engines having Corliss valves should be equipped with a "low plane" governor stop, which would shut down the engine if the governor weight should drop to its lowest position through interference with its driving arrangement or from any other cause.

The safety bracket shown in Fig. 3 can be placed in position "A" before the engineer shuts off steam. As the governor weight lowers, the bracket supports it, being carried out to position "B."

This permits the engine to be started freely. After the governor rises to its normal running position, the bracket drops by gravity to position "C," thus bringing the stop into operating condition.

Fig. 2 shows a rod connected to a governor bracket so the engineer can hold it "in" while he is shutting down the engine. A spring pulls the bracket "out" after the engine has started.

Fig. 1 shows a counterweighted lever, for use where there is danger of the engine shutting down through temporary overloads. The counterweight affords some support to the governor at such times and prevents the engine from stopping. In case the entire weight of the governor is brought to bear, however, the counterweight is lifted and the automatic stop operates.

Note guard around governor balls, disc in governor sheave and railing around same (Fig. 2), also plate enclosure around fly-wheel (Fig. 1).

These engines have independent electric stops and speed-limiting devices, one of the former being just visible at the right-hand side of Fig. 2.

Fig. 3. Automatic Safety Bracket for Engine Governor.*

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

AIR COMPRESSORS PUMPING ENGINES, GAS, ENGINES, ETC.

Many of the foregoing provisions are applicable to air compressors, pumping engines and gas engines, as well as steam engines. The following additional precautions should also be observed for such equipment: —

Air Compressors

"Explosions in air compressors and receivers occur with sufficient frequency to demand careful attention. The majority of such explosions are undoubtedly due, either directly or indirectly, to the lubricating oil used in the air cylinders. Poor working conditions of the compressor, such as leaking valves, hot and dirty inlet air, insufficient cooling water, carbon deposit in cylinder or connections, and high speeds of poorly designed compressors, all assist in producing dangerously high temperatures of the compressed air. These high temperatures are sufficient to ignite the volatile constituents of the lubricating oil, and produce violent explosions; therefore, —

(*a*) Keep the temperature of the compressed air, during compression, as low as possible.

(*b*) Keep the piston and valves tight, and in good working condition.

(*c*) Take the inlet air from as cool and clean a location as practicable.

(*d*) Use plenty of cold water, from a source which is not liable to fail, and have it visible at discharge from cylinders or coolers.

(*e*) Do not use kerosene or other volatile substances in the cylinder, tanks or any connections.

(*f*) Use mechanical or sight-feed oilers for the compressor cylinder.

(*g*) Use the least amount practicable of the best air cylinder oil. Air cylinders require much less oil than steam cylinders.

(*h*) Never use steam cylinder oil in an air cylinder.

(*i*) Keep the cylinder, tanks and connections as free from carbon, accumulated oil and deposits, as practicable.

(*j*) A good cylinder oil is one which lubricates well, leaves little or no deposit, is the least volatile at high temperatures and has a high flash point.

It is also recommended that safety valves on compressed air tanks should be large enough to prevent over-pressure in case the compressor should run at 50% over designated speed. A standard 11 × 15" manhole or equivalent means of access is desirable in every pressure tank 36" or more in diameter, also openings for removing foul air from highest point of tank and draining any accumulation of moisture from the lowest point.

Pumping Engines

Where pumping engines are intended to maintain a fixed discharge pressure, they are sometimes controlled by a pressure regulator only.

This may give rise to a dangerous condition. If there should be a break in the discharge line, which would relieve the pressure, more steam would be admitted, although the load would be released. The engine would speed up and might quickly wreck itself if not checked.

Under such conditions it is important to provide some auxiliary means of control. This may take the form of a fly-ball governor which will shut off the steam supply in case of excessive speed. An automatic engine stop with speed limit or other similar device can also be used.

Gas Engines

The following rules for gas engines are taken from the standards proposed by the standardization Committee of the National Safety Council: —

"Toilets, rooms, or places where men may gather shall not be allowed in any gas-engine basement.

In the installation of new engines as little of the machinery and appliances as possible shall be placed in the basements.

If engine has a gas bag regulator, the regulator shall be enclosed in a metal case, vented to outside atmosphere." (See also Chapter 33.)

CHAPTER 13

ELECTRICITY

ELECTRICITY furnishes the best power medium from the standpoint of safety, if properly utilized. (See Chapter 14.) Unless safety features are given careful consideration at the time the equipment is installed, however, this fundamental advantage may be offset by the introduction of a special electrical hazard.

CAUSES OF ACCIDENTS

The nature of the electrical hazard is well illustrated by the list of electric shock accidents given on Page 108. It should be explained that no attempt has been made to include the complete experience of any one company or period in this list, so no conclusions can be drawn from it in regard to the relative frequency of the different kinds of accidents represented. It does give interesting details, however, on thirty-five actual cases of electric shock, twenty-two of which were fatal.

Several significant facts relating to the electrical hazard may be gained from a study of this list: —

(*a*) Effect of Voltage

As showing that thorough contact with even the higher voltages for an appreciable length of time is not necessarily fatal, cases Nos. 32 and 34 may be cited. In one of these a man recovered after contact with a 33,000 volt circuit, and in the other the injured man lived two weeks after contact with a 66,000 volt circuit, dying ultimately as a result of the burns and sloughing off of the injured parts and not from the immediate effect of the shock.

On the other hand, under certain conditions, death may be caused by low voltages; while the lowest voltage mentioned in this list from which death occurred is 380 (case No. 3), death from 220 and even 110 volt systems is not unknown.

Two conclusions as regards voltage may accordingly be drawn: —

(1) It may be possible to resuscitate victims of high-tension electric shock; the necessary provisions for that end should be made and every effort put forth in case of such accidents.

(2) While the hazard of low-tension systems is relatively smaller, there is still sufficient danger to necessitate care in handling such equipment, and certain precautions in the way of safeguarding it.

(*b*) Grounding Devices

The use of proper grounding facilities would have prevented eleven of these accidents, eight of which were fatal. The application of the ground would either have shown that the apparatus was alive, or would have prevented its becoming so while it was being worked upon.

In one case (No. 33), a bare copper wire was used as a grounding device, — a most inadequate arrangement but not an exceptional one. This resulted in the death of the man who was removing the ground wire.

In six cases a mistake was made in the circuits, or the circuits were unexpectedly alive. In one instance wires became crossed. In another the shock was received from a transformer case; this could not have occurred if the case had been properly grounded.

(*c*) Resuscitation

The Prone Pressure method of resuscitation was effective in saving the lives of ten out of the twelve persons to whom it was applied. Two recoveries are also reported from the use of the Sylvester method, although, as mentioned under "Resuscitation" (Chapter 51) this is less effective than the Prone Pressure method.

(*d*) Working Alone

In six of the fatal cases the injured man was alone at the time of the accident, and therefore had no chance to be resuscitated. If a second

SERIOUS ELECTRIC SHOCK ACCIDENTS

No.	State Year	AC–DC Volts	Injured employed as	Person working on or at	Reasons for Shock or Burns	Injuries and Body Contacts	Kind and Time of Treatment	Result
1	Mass. 1902	AC 550	Chief Electrician	Motor circuit wiring	Power thrown on to circuit	Burns: Left hand and right elbow	Rubbing	Death
2	Mass. 1912	DC 550	Trackman (Rapid Transit)	Tightening track screws	Wrench fell across third rail and ground rail	Heavy body burns	Hospital	Death
3	Mass. 1913	AC 380	Station Operator	Cleaning knife switch	Hands clasped knife blades	Hands burned off	Alone	Death
4	Mass. 1913	DC 550	Motor Attendant	Cleaning shop motor	Shock threw him against motor terminal block	Shock and burns: Forehead	Prone pressure	Recovered
5	Mass. 1913	AC 550	Crane Operator	Sitting in crane cab	Fell off seat, striking switch	Shock and face burns	Prone pressure Five minutes	Recovered
6	Mass. 1913	AC 2300	Station Operator	On rear of switchboard	Slipped against live parts	Heavy burn: Face	Prone pressure Hospital	Recovered
7	Penn. 1910	AC 2300	Crane Operator	Walking along test floor	Stepped on exposed terminals of test circuit	Shock: Feet	Prone pressure	Death
8	Mass. 1912	AC 2300	Station Operator	Operating compressor switch	Put hands on live parts of switch	Shock: Hands	Sylvester method	Recovered
9	Mass. 1895	AC 2300	Lineman	Working on pole	Came in contact with live wires	Shock: Hands	Sylvester method	Recovered
10	Penn. 1913	AC 8000	Station Wireman	Working on switchboard wiring	Circuit unexpectedly alive	Burns: Hands and back	Prone pressure Fifteen minutes	Recovered
11	N.Y. 1905	AC 2000	Lamp Trimmer	Series lamp on street	Handling live circuit	Shock: Hands and feet	Sylvester method	Death
12	N.Y. 1905	AC 4400	Testing Foreman	Replacing voltage wires	Hand touched live bus	Shock: Hands and feet	Sylvester method	Death
13	Mass.	AC 2300	Stock Clerk	Helping at rear of switchboard	Slipped against live parts	Shock	......	Death
14		AC 2300	Line Foreman	Wires on pole line	Crossed on to a live line (wet day)	Shock and fall	......	Death
15		AC 2300	Lineman's Helper	Fuse of transformer on pole	Transformer case became charged	Shock and fall	......	Death
16		AC 2000	Lineman	Lamp bracket of street arc	Mistake in choosing between two circuits	Shock	......	Death
17		AC 2300	Chief Electrician	On planking over switchboard	Got against live wiring	Burns: Chest	......	Death
18	Mass. 1913	AC 2000	Test man	Walking on test floor	Stepped on live parts	Shock: Feet	Prone pressure Fifteen minutes	Recovered
19	Mass. 1913	AC 5000	Test man	Taking down test wiring	Circuit was accidentally alive	Shock: Elbow and hand	Prone pressure Half a minute	Recovered
20	N.Y. 1905	AC 13,000	Test man on generator	Reading thermometer	Defective insulation	Shock: Head and body	......	Death
21	Mass. 1904	AC 13,000	Laborer	Cleaning bus room	Touched bus bar	Shock: Hand and foot	Alone	Death
22	Mass. 1907	AC 13,000	Station Operator	Dusting multigap arresters	Touched live parts	Shock: Hand and foot	Alone	Death
23	Mass. 1910	AC 13,000	Station Operator	Wiping top of switch compartment	Touched lug of live cable with hand	Shock: Hand and foot	Alone	Death
24	Mass. 1913	AC 13,000	Station Operator	On ladder near live wiring	Slipped against live wiring	Shock: Clothing burned	Alone	Death
25	Mass. 1913	AC 13,000	Wireman's Helper	Making out time slip	Leaned back carelessly against live wires	Shock and burns: Back	Pulmotor Twenty minutes	Death
26	Mass. 1913	AC 5000?	Lineman	Opening line wires on pole	Rotary in sub-station fed back charging line	Shock: Leg	Two doctors	Death
27	Mass. 1913	AC 12,000	Millwright	Boring timbers	Tool swung against wires of testing circuit	Shock: Hands and feet	Prone pressure Thirty minutes	Recovered
28	N.Y. 1913	AC 11,000	Station Operator	Opening disconnect switches in bus room	Opened wrong group of switches by mistake	Heavy burns	Hospital	Death
29	Penn. 1908	AC 10,000	Test man	Test	Opened circuit while alive by mistake	Burns: Hands and back	Prone pressure	Recovered: Two fingers amputated
30	Penn.	AC 11,000	Tester's Helper	Testing transformer	Without consulting tester caught live conductors to open circuit	Heavy burns: Hands	Sylvester method	Recovered: Two hands amputated
31	Mass. 1913	AC 15,000	Test man	Taking down transformer connections	Took hold of terminal that was alive by mistake	Shock: Hand and foot	Prone pressure Five minutes	Recovered
32	Wash. 1902	AC 33,000	Station Foreman	Multigap arresters	Slipped against live parts	Burns: Hands and foot	Two arms and heel amputated	Recovered
33	Mass. 1913	AC static (66,000)	Lineman	Telephone line on trans. tower	Removing ground from telephone wires	Shock: Hands and back	None	Death
34	Mass. 1914	AC 66,000	Station Foreman	Cleaning oil switch bushings	Forgot to open disconnects on both sides of work	Heavy burns: Chest	Hospital: Two weeks	Death
35	Mass. 1913	AC 66,000	Teamster	Removing chain from transformer	Raised head too near line wire	Shock	Prone pressure Two hours	Death

man had been present, some of these lives would undoubtedly have been saved.

(*e*) **Screens**

In eleven cases accidental contact was made with live circuits either on account of a slip and a resultant unexpected movement, or on account of the injured person failing to realize that a live conductor was near. Such accidents are largely preventable through the installation of proper screens or other forms of enclosure. (See Pages 111, 118, and 119.)

(*f*) **Working on Live Circuits**

In five cases, three of them fatal, the men were working on live circuits, — a practice which should be discouraged and reduced to the minimum.

(*g*) **Cleaning**

Six fatal injuries were received while cleaning equipment; this shows conclusively the need for definite rules governing such work and the omission of more frequent cleanings than are absolutely necessary. (See Page 121.)

(*h*) **Locking Devices**

No. 1 illustrates the need for locking switches of circuits which are being worked upon, to prevent their being thrown in accidentally. (Page 114.)

(*i*) **Insulation Breakdown**

No. 20 is an illustration of the fact that the insulation on high voltage wires should be not depended upon where a question of human safety is involved.* (See Fig. 3, P. 113.)

(*j*) **Cut-Out Hanger**

The use of a cut-out hanger which automatically renders the lamp dead (see Page 59), would probably have prevented the fatal injury described in case No. 11.

(*k*) **Human Element**

In several instances a man was killed as the result of a simple act of forgetfulness on his own part, such as neglecting to pull disconnect switches on both sides of the apparatus upon which he was about to work. (See No. 34.) These accidents generally occurred to old and experienced men who were thoroughly familiar with the hazard, — and not to "green" hands as might be expected. This shows the familiar "human element," and indicates that every possible precaution should be taken for the prevention of such injuries. These precautions should include not only mechanical safeguards, but definite rules for carrying on routine and emergency work.

Standards for the construction and installation of electrical equipment and operating rules for the care and maintenance of same, are of primary importance. While the National Electrical Code has been developed with the fire hazard principally in mind, it is difficult in many cases to draw the line between fire hazard and life hazard; the N. E. C. rules accordingly contain much material which is of value in safeguarding human life.

The need of additional safety precautions, however, has been recognized for some years and this has resulted in the preparation of safety rules by a number of industrial concerns for their own guidance.

In 1914 the Bureau of Standards of the U.S. Department of Commerce (Washington, D.C.) undertook the development of electrical safety standards which could be accepted as authoritative throughout the country. This work has now been in progress for more than a year (June, 1915). Much valuable service has already been done in the way of unifying the ideas of those interested, conferences having been held with representatives of state and municipal commissions, industrial concerns, electrical associations, insurance companies, etc. A preliminary edition of the standards has been issued as circular No. 54 "Proposed National Electrical Safety Code," dated April 29th, 1915. (The operating rules were published separately as Bulletin No. 49, dated May 4th, 1915.)

This material consists of some two hundred pages, and space will not permit of its being reproduced here. Copies can be obtained at a nominal price upon application to the Bureau,

* Since this was written another fatal accident has occurred in Massachusetts as the result of an electrician coming in contact with the lead sheath of an insulated cable; the men in this particular plant had previously felt that such insulation was ample, and that the cable could be handled with entire safety.

and it is strongly recommended that all those who have to do with electrical equipment secure copies of these Bulletins.

In the following pages will be given a brief discussion of some important safety features which are of special interest, with a number of quotations of general rules from the Bureau of Standards code (hereafter referred to as the "Safety Code"). For detailed requirements, however, reference should be made to the Code proper. While the latter has not been finally approved at the time this material goes to press, it is undoubtedly in approximately final form.

VOLTAGE

In determining the voltage to be adopted for an industrial plant, it should be borne in mind that the hazard to human life increases with the increase in voltage; as in the use of steam, higher pressures give more economical results, but they require correspondingly greater safety precautions, and when an accident does occur it is more likely to involve serious injury to employees.

For small motors, lights and general service inside industrial plants, 110 or 220 volt installations are recommended. Where it is necessary, on account of the use of large motors or other considerations, to use higher voltages, correspondingly greater precautions should be taken to guard against accidents.

The use of the series lighting system inside buildings has resulted in many fatalities. It is fortunate that the tendency has been to replace this system with the less hazardous low-tension multiple system. In view of the general trend in this direction, it is probably unnecessary to issue a warning against the installation of series arc lighting for new installations in industrial plants.

CONTROL

Several important safety features, from the standpoint of control are available through the installation of motor-driven equipment. Among these the following are important and should be given consideration when new installations are being made:—

Individual motor drives are to be preferred, as this gives the most facile means of control. The switch can be located close to the machine, thus permitting power to be shut off promptly in case of accident or for repairs, etc. Furthermore, the use of individual drives does away entirely with the long lines of transmission shafting and belting common in engine-driven plants. (See Figs. 1 and 2, Page 113.)

Group motor drives are second in desirability. The groups should be small in order to keep the control as simple and convenient as possible, and reduce to the minimum the use of transmission shafting and belting.

There is an operating advantage in this method of driving, in that any group of machines which is not being operated can be cut out entirely, thus saving wear and tear on the main shafting and belts. The ability to shut down a small group independently, without interfering with other equipment, has a distinct advantage from the safety standpoint in that it facilitates the proper stoppage of machinery when repairs or adjustments are being made. Where the groups are large or where there is but one source of power for an entire plant, shutting down this main power supply involves serious delay and loss of time. There is accordingly a tendency to take chances in doing emergency work such as replacing belts, etc., with the power on. This has caused many serious accidents, and in some engine-driven plants it is the practice to shut down the particular machine or group involved, for work of this kind, until the engine is stopped at the end of the turn.

The inconvenience of following this practice, and the dangers of its alternative, are both avoided by the use of individual or small-group motor drives.

Distant control (i.e.,by means of push-buttons, etc.) is important where machines are located on a different floor from the driving motor, or where they are arranged in large groups. In ordering new circuit breakers, magnetic switches, etc., they can be obtained in designs adapted to the application of push-button control systems. (See Figs. 1, 2, and 3, Page 111.) Where

Fig. 1.

Fig. 2.

Fig. 3.

Figs. 1, 2, and 3 show standard makes of Circuit-Breakers, "Magnetic" and Oil Switches, with solenoid trips which can be operated by push-buttons for shutting off power from a distance. In ordering new equipment for machinery drives this feature should be specified.

Fig. 4. Guards for Electrolytic Lightning Arresters, — 6600 Volts.

Fig. 5. Guard for 66,000 Volt Wire within reach of Platform.

Fig. 6. Guard for Exposed Portions of 6600 Volt Underground Cables.

Fig. 7. Ground Connection on High-Tension Tower.

Fig. 8. Grounding Clamp used in Fig. 7, — applied and removed with a switch stick.

Fig. 9. Grounding Sticks for Station Service.

The clamp shown in Figs. 7 and 8 can be used for making temporary connections of various sorts, as well as for a grounding attachment. An eight-foot switchstick is provided for manipulating it. The sticks shown in Fig. 9 have portable leads with one end permanently connected to ground. These devices are hooked on circuits, to ground them.

push-button control is used for machinery which is not immediately adjacent to and within sight of the push-button, it is desirable to have the arrangement such that a push-button can be used to throw off the current and *stop* the operation, but *not* to *start* it again. This is to avoid danger of catching some one unawares and causing an injury by the unexpected starting of the equipment.

For a further discussion of power control, quick-stopping devices, etc., see Chapter 14.

Speed limiting devices are specified for individual equipment in the proposed Safety Code, as follows: —

120. (*a*) Prime movers driving generating equipment should be provided with automatic speed-limiting devices (in addition to the governors) where harmful overspeed can otherwise occur.

(*b*) Separately excited d.c. motors and motor-generators, and converters where it is possible for them to be driven from the d.c. end by a reversal of current, shall be provided with speed-limiting devices.

(*c*) Where the speed control of dire t current motors is accomplished by varying the field resistance, the field rheostats shall be arranged with "no voltage releases" or other devices so that the motor can not be started under dangerously weakened field.

The use of locks on controlling switches is recommended for the protection of persons working on the equipment controlled. (See Pages 114 and 115.)

Dynamic braking. In the control of motor-driven equipment the dynamic braking principle can frequently be used to advantage where quick stopping is important from the safety standpoint.

There are many kinds of equipment in which the momentum of moving parts is sufficient to keep the machinery running for some time after the power has been cut off. Mechanical brakes have been used more or less for checking the machinery under such conditions. In stopping a moving part the energy due to its momentum must be absorbed or converted into heat. With a mechanical brake this energy is dissipated by friction on the braking surface, with consequent wear and tear, involving expense for maintenance and replacement.

In dynamic braking the motor is converted, temporarily, into a generator. Some of the energy may be actually returned to the line, so that it is not lost, and the remainder is converted into heat and radiated from resistance units or other parts suitably designed for this purpose, without any wearing away of working parts.

Where dynamic braking is employed, by varying the resistance the time required to stop the equipment can be varied and reduced to a minimum safe limit.

It thus follows that dynamic braking can be used as a form of electric control, to give an efficient and economical quick-stopping arrangement. It is also of value as a control feature for electric traveling cranes. (See Page 178.)

PROTECTION OF LIVE PARTS

Live electrical parts should be protected in such a manner as will prevent accidental contact with persons, tools, materials which are being handled, etc. Such protection may be afforded in two ways, by (1) Isolation, and (2) Guarding.

Isolation. So far as practicable electrical equipment should be located in separate buildings or rooms. Where necessarily located within a work-room, the equipment should be installed in a separate compartment or otherwise suitably screened or fenced off. (See Page 127.)

Such buildings, rooms or compartments should preferably be kept locked, and marked with notices warning against the entrance of unauthorized persons. No equipment or process no tessential to the electrical operation should be permitted in such rooms or compartments.

Isolation by means of elevation, that is, by locating the equipment at such heights above floors or platforms as will make it relatively inaccessible, is of considerable value. (See item 116 of the Safety Code.) The fact should not be lost sight of, however, that some special condition may cause employees to climb to elevations

Fig. 1. Individual Motor Drives.

Fig. 2. Belt and Shafting Drives.

Fig. 3. Sub-Station Accident.

Figs. 1 and 2 show shops, in one of which the machines are driven by individual motors, — in the other by belts and overhead shafting. The reduced accident hazard in the former case is apparent; the danger from oiling and taking care of overhead shafting has been entirely eliminated, and that of belts and pulleys for individual machines, practically so.

Fig. 3 shows where a man was killed in a high-tension sub-station. He made contact between the temporary wiring (insulated) at the top of the picture, and the concrete structure at the point indicated by the arrow. This illustrates the necessity for screening or guarding even temporary installations; it further emphasizes the fact that the insulation of high-tension conductors should not be depended upon for human safety.

Fig. 4 shows where a child was killed, by standing on the roof of a sub-station and grasping the two high-tension wires leading downward from the cross-arm. The splices where these wires were burned off by the contact are still visible (see arrow).

All such equipment should be so arranged as to thoroughly guard against the possibility of unauthorized persons gaining access to it. In this case the child climbed over the ordinary board fence shown in the picture.

Fig. 4. Accident on Roof.

Fig. 1. Switch with Locking Device.

Fig. 2. Switch Enclosure in Plant.

Fig. 3. Enclosed Switchboard for Motor-Driven Planer.

Fig. 4. Enclosed Snap Switches.

Fig. 5. Rheostat with Cover.

Where electrical machinery or apparatus is so located that it is invisible from the main controlling-switch, a man working on the wiring or machinery controlled might be injured by having the current thrown on by some one at the switch who was unaware of his position.

A locking device is the best method of guarding against accidents of this kind. The man for whose benefit the lock is being used should keep the key, and remove the lock only when he is through with his work in this location.

Fig. 1 shows a switch arranged so that it can be locked in the off position. The slotted opening is large enough to allow two or more locks to be placed in it at once; so that if more than one gang is at work on the machinery controlled by the switch, each one can be protected by its own lock until all work is completed and the men are out of danger.

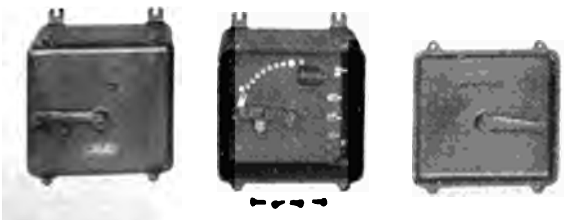


Fig. 6. Enclosed Rheostat.

Where switches are located so that there is danger of accidental contact with them they should either be of the enclosed type shown on Page 115, or provided with cabinets such as are illustrated in Figs. 2, 3, and 4. The enclosure in Fig. 4 is of asbestos board.

Figs. 5 and 6 show standard makes of enclosed rheostats.

Unless enclosures of this kind are of asbestos board or other suitable insulating material, they should be permanently grounded, in order to prevent their beccming accidentally charged and injuring persons who touch them.

Fig. 1-A. Switch Open, with Fuses "dead."

Fig. 1-B. Switch Closed.

Fig. 2. Enclosed Switch, with Lock.

Fig. 3. Enclosed Switch with Locking Device.

Figs. 1, 2, 3, and 4 illustrate standard makes of enclosed switches, each arranged so it can be locked. Switches 1 and 3 are thrown out automatically when the covers are opened, the construction in Fig. 1 making certain that the fuses will be "dead" before any work can be done on them. In Fig. 5, the outside switch-lever is dead and the case grounded.

Oil switches are shown in Figs. 4 and 6.

It will be noted that the current-carrying parts illustrated on this page are all thoroughly enclosed. Where such apparatus is used in conjunction with grounded metal conduits, the danger of injury from accidental contact with live parts has been practically eliminated.

Fig. 4. Oil Switch with thorough Enclosure.

Fig. 5. Enc. Switch, Lever "dead."

Fig. 6. Oil Switch with Case opened to show Construction.

which might ordinarily be considered safe. Painting, whitewashing, replacing a belt, adjusting an electric light or other similar work of a relatively infrequent character, may bring some one in contact with equipment located high above the floor.

Under such conditions even a slight shock may cause a fall and result in injury even though the shock itself is not severe. It is accordingly recommended that all electrical equipment from which dangerous shocks may be received in such ways be provided with barriers or screens which will eliminate danger of accidental contact.

Guarding. Individual items of equipment, wiring, etc., which might result in personal injuries, should be so guarded or enclosed as to prevent danger of their being touched.

The situation as regards electrical equipment is not unlike that of the mechanical hazards of gearing and belting, with this exception, — mere contact may cause an injury in the case of electrical equipment, whereas it is necessary for persons to be actually caught at a certain point in gearing or belting. In either form of hazard a slip or mis-move may result in injury from an exposed part. Even where the voltage is low, a slipping tool, a piece of pipe or other metal which is being carried, etc., brought into accidental contact with live conductors may cause serious burns or flashes.*

Item 115 of the Safety Code is as follows: —

Protection shall be provided for persons near otherwise exposed ungrounded current carrying parts of electrical supply equipment (such as the terminals of generators, and motors, bus bars, and other conductors), operating at over 150 volts to ground and not effectively isolated by elevation, as follows: —

(*a*) Where the working space about electrical equipment is less than that specified in rule 114*a* and 114*b* (see Page 117), suitable inclosures or barriers shall be provided to prevent inadvertent contact with live parts. If such inclosures must be opened or barriers removed while the parts they guard are alive, all surrounding floors within reach shall be provided with suitable insulating platforms or mats.

Inclosures may consist of casings or suitable insulating coverings. Insulating coverings of conductors should be depended upon only when very substantial, thoroughly dry, and containing no non-insulating flame-proofing compound.

Barriers may consist of horizontal or vertical strips placed in front of live parts, or of closely spaced partitions between the live parts, extending beyond the latter on the exposed sides.

Where covers, casings, or barriers must at any time be removed while the parts they guard are alive, they should be of insulating material.

(*b*) Where the specified working spaces are provided and the live parts are not guarded by inclosures or barriers, the insulating platforms or mats shall always be provided.

(*c*) Where the live parts operate at over 7500 volts the inclosing or barrier guards shall always be provided, even where insulating mats are also provided.

Inclosing or barrier guards not of grounded metal should be of substantial insulating material and so spaced from the live parts as to prevent persons from approaching nearer than three times the needle point sparking distance of the voltage concerned.

For the protection of electrical equipment (not over 750 volts) in industrial plants, the following standards, similar to those for mechanical protection, are suggested: —

Standards

Railings or enclosures, if used to protect electrical equipment, shall be of substantial construction, conforming to standards outlined in Chapter 10, and of such size and arrangement that an arm (assumed to be 2′ 6″ in length) of a person outside the railing or enclosure cannot project through, over, or around it and make contact with any live part.

Where railings used for such guards are located within 2′ 6″ of live parts, the railings shall be covered with wire fabric, sheet metal or other suitable material, at all points where an arm projected through the railing might make contact with live parts.

Where a guard or enclosure is within 4″ of current-carrying parts located 7′ or less above the floor, and there are openings through the guard more than ⅜″ in width, such openings shall be completely covered or protected by some suitable material such as wire netting of not more than ⅜″ square mesh, not smaller than No. 20 gage wire.

* For an excellent discussion of Electric Flash and kindred topics, together with approved methods of treating such injuries, see "Electrical Injuries" by Chas. A. Lauffer. (John Wiley & Sons. 1912.)

GROUNDING

There are three general forms of grounding, all of which are of vital importance from the safety standpoint.

(1) **Grounding of dead metal parts** (such as frames of generators, motors, and switchboards, cases of transformers and oil switches, metal conduit and cable sheaths) prevents danger of such parts becoming accidentally charged and injuring employees who touch them inadvertently or under the supposition that they are not alive.

Instructions covering this form of grounding are found in the National Electrical Code; it is also referred to in Rules 113 and 206 of the Safety Code.

(2) **Grounding of (low potential) secondary circuits** prevents danger of accidents which might otherwise occur from leakage of primary current through the transformers, crossed wires, etc. Where such grounding is omitted, employees may be injured by high-tension current where they anticipated only the low-tension secondary current.

This form of grounding is required by Rule 15 of the National Electrical Code, to which reference should be made for detailed instructions.

(3) **Grounding of equipment worked upon** (in addition to throwing out the switches controlling it) makes certain that accidents will not be caused from (*a*) failure to disconnect all sources of current supply before the work is started, and (*b*) charging of the equipment while the work is underway, through the accidental closing of a switch, "crossing" or break-down of another conductor, etc.

A typical accident occurring in Massachusetts in 1914 may be cited by way of illustrating the importance of always complying with this precaution.

Some work was to be done on a high-tension line, and the station switches were thrown out and the line reported ready for work. As the job required only a few minutes time, the customary precaution of grounding the line at the place where the work was to be done was neglected, and a man who caught hold of the wire was electrocuted. It was found, upon investigation, that a rotary converter used to supply the low-tension side of the system had inverted from power supplied through an additional source, and the high-tension side of the line was thus charged by it.

Obviously the grounding device should be of such design, and the method of applying and removing it such as to eliminate hazard while handling it. (See "Grounding Devices," Pages 111 and 118.)

Instructions for the use of this form of grounding are given in Sections 44–47 of the Safety Code, to which reference should be made for further details.

SPACE ABOUT ELECTRICAL EQUIPMENT

It is an essential safety precaution that sufficient space be provided around electrical equipment, lines, etc., that persons need not be brought into dangerous proximity with live equipment.

Rule 114 of the Safety Code relating to working space about electrical equipment is as follows: —

> Adequate working space with secure footing shall be maintained about all electrical supply equipment which requires adjustment or examination during operation. Moving parts in these spaces shall be provided with approved barrier guards.
>
> > Working spaces about live parts over 150 volts to ground shall be made inaccessible to other than authorized attendants by the use of suitable barriers when necessary.
>
> The spaces shall be so arranged as to give the authorized attendants ready and safe access to all parts requiring attention, and should, where practicable, provide the following minimum working spaces: —
>
> (*a*) If there are exposed live parts up to 750 volts on one side, the minimum width should be 2½ feet; above 750 volts, at least 3 feet.
>
> (*b*) If there are exposed live parts up to 750 volts on both sides, the minimum width should be 3 feet; above 750 volts, at least 5 feet.
>
> (*c*) All working spaces shall have safe exits provided. When the space is narrow and exceeds 10 feet in length, it is recommended that exits shall be provided at both ends.

Fig. 1.

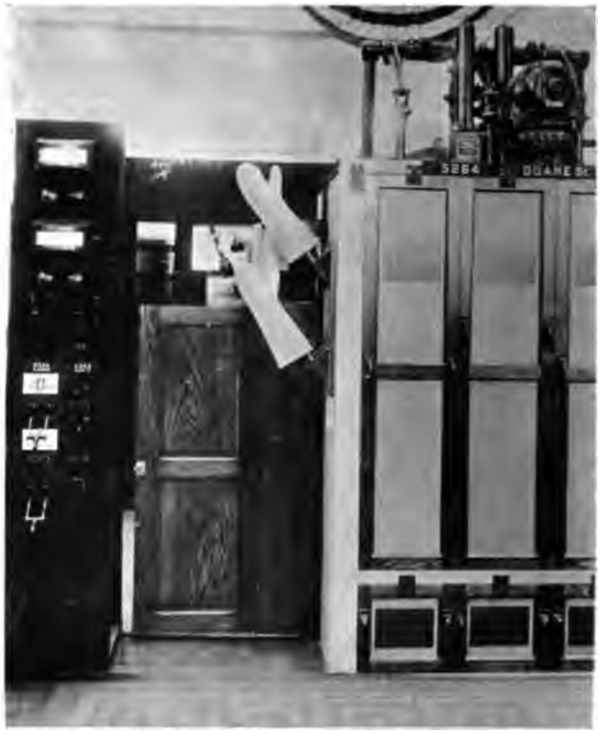


Fig. 2.

Safety Appliances for Electrical Equipment.*

Fig. 3. Ground Connections, etc.*

These photographs illustrate model safety equipment. Fig. 1 shows a ground testing and discharging stick to be used in making sure that the circuit is dead before grounding it. One end of the test cable is permanently connected to the ground wire through an expulsion fuse, and provision is made for testing the device for continuity before using it, by touching its free end to the circular plate which will be noted underneath the electric lamp.

As a further precaution, employees are instructed to use rubber gloves, samples of which are shown at the right of this picture (and in Fig. 2).

Fig. 2 illustrates well-guarded switch compartments. At the left will be noted a low-tension switchboard containing standard remote control and metering devices. This exhibits the use of tags for marking the various lines when work is being done on them.

Fig. 3 shows portable ground connections of large capacity, to be used in bus compartments. Attention is directed to the ground attachment into which the device at the right is plugged; also to the permanent ground for the switch-operating mechanism. A pair of wooden tongs for removing high-tension transformer fuses hangs at the left of the first-aid kit.

* Courtesy of The New York Edison Company.

Fig. 1. High-Tension Equipment. (New York Edison Company.)

Fig. 2. High-Tension Towers. (National Tube Company.)

Fig. 1 shows high-tension switch and bus compartments. It will be noted that each compartment is provided with an individual cover, wired glass being used for buses and ventilated asbestos-board for oil switches. In order to avoid confusion each set is numbered. As a further precaution, physical separation or barriers may be used to prevent danger of mistaking phases of different circuits.

Fig. 2 shows high-tension distributing towers in a mill yard. The poles are marked with special warning signs (B) and the steps are removed to a height which would discourage unauthorized persons from climbing the poles.

Working platforms with railings (A) will be noted underneath the cross-arms. Grounded lightning conductors (D) are placed over the lines, and a separate visible grounding wire (C) is provided for each tower.

Fig. 3 shows oil switch compartments with remote control operation. Note ample working space provided about this equipment. Each compartment is provided with a card designating its service. There is a space between the different lines, to avoid possible confusion of phases.

Fig. 3. High-Tension Station. (Boston Elevated Railway Company.*)

* Courtesy of Stone and Webster Engineering Corporation.

Adequate climbing space on poles is also an important safety consideration and one which is frequently neglected. This is covered, with certain specified distances to be maintained, in Rule 54 of the Safety Code.

Signal lines (viz. for telephone, telegraph, messenger or fire-alarm systems, etc.) should be placed on separate poles from those carrying high-tension wiring, if at all practicable. The practice of placing such low-tension wires on high-tension poles, from the standpoint of hazard to life, is not unlike that of locating manufacturing equipment in a high-tension electric station.

Where local conditions necessitate the same poles being used for both wires, proper clearances and adequate arrangement and spacing to minimize the danger should be insisted upon. These matters are covered in Sections 21, 25, and 39 of the Safety Code.

Temporary barriers should be provided where new construction or alterations necessitate men working in close proximity to high-tension electrical wiring or other equipment. Under such conditions the workmen cannot be expected to be constantly on the alert with the danger of injury always fresh in mind. Many deaths have occurred from a moment's thoughtlessness in such circumstances, which might have been avoided by the erection of a temporary railing or guard. (See Fig. 3, P. 113.)

GENERAL RULES FROM THE CODE

The following rules, of a general nature, are quoted from Part 1 of the preliminary Safety Code (issue of April 29, 1915). These, and additional rules of a specific character, are taken up in other parts of the Code, in their application to particular types of electrical equipment: —

101. **Illumination**

(*a*) Rooms and spaces shall have good artificial illumination. Arrangements of permanent fixtures and plug receptacles shall be such that portable cords need not be brought into dangerous proximity to live electrical apparatus. All lamps shall be arranged to be controlled, replaced, or trimmed from safely accessible points.

Ladders do not provide safe means for reaching lamps which are above live or moving parts, or over 15 feet above the floor.

(*b*) A separate emergency source of illumination from an independent generator, storage battery, gas mains, or other suitable source shall be provided in every station where an attendant is located.

It is recommended that this emergency source be permanently in use where practicable.

The operator should not be exposed to the danger of opening and closing switches (and other operations about live parts) in rooms suddenly darkened by the failure of current.

In some cases emergency lamps are automatically lighted by the failure of the ordinary energy supply.

In certain cases oil lanterns may provide a sufficient emergency source of illumination.

Many stations are equipped with a storage battery for the purpose of supplying emergency illumination. In some instances this battery is specially provided for the purpose, while in others it is used to supply energy for operating relay systems and similar essential equipment. The addition of an automatic relay or other device which will throw this source on the lighting system when the regular illumination fails has found much favor.

103. **Floors, Floor Openings, Passageways, Stairs**

(*a*) Floors shall be level and afford secure footings.

Nails, loose boards, uneven or greasy wood floors, and smooth iron floors should be avoided.

(*b*) Passageways (including stairways) and working spaces shall be unobstructed and should provide at least 6½ feet head room.

(*c*) All floor openings over 2 feet deep, and all stairways or raised platforms over 4 feet high (except loading platforms) shall be provided with approved handrails.

Except for loading platforms, such rails are recommended where height exceeds 2 feet, especially where they are adjacent to live or moving parts, or the working space on the platform is restricted.

(*d*) All openings in floors over 6 feet deep, the edges of all raised platforms over 6 feet high, and the backs of all stairway treads should be provided with suitable toe-boards.

Falls, hitting obstructions, and other mechanical accidents are responsible for the greater proportion of all personal injuries in stations.

Particularly bad is the placing of lockers back of switchboards or in bus chambers. The mere unnecessary presence of persons in such places is dangerous; and the removing of clothing causes movements of the arms and stepping about, very liable to cause dangerous contacts or approach to live parts.

104. **Exits**

Each room or space and each working space about such equipment shall have safe means of exit which shall be kept clear of all obstructions.

Where practicable there shall be at least two separate exits from each room, inclosure, platform, or passageway exceeding 10 feet in length.

105. **Fire Appliances**

Each room or space where an operator is in attendance shall be provided with adequate approved fire-extinguishing appliances, located conveniently and rendered conspicuous by suitable marking. Any such appliances which cannot be safely used on live parts should be plainly and conspicuously marked with a warning to that effect.

Use of ordinary sodium carbonate extinguisher on live parts endangers the operator, as does also the use of a hose stream of short length, and both may seriously injure the electrical equipment itself. Use of such liquids as carbon tetrachloride, on the other hand, entails no danger of shock, if the person does not bring the metal container into actual contact with live parts.

111. **Inspections (Cleaning, etc.)**

Electrical supply equipment with its associated guards and appliances (*a*) shall comply with these safety rules before being placed in use; (*b*) shall thereafter be systematically examined, inspected, cleaned, and any defects recorded on the station log.

Cleaning High-Tension Equipment (Author's discussion.)

While it is possible to outline precautions which will make the cleaning of this equipment entirely safe provided these precautions are followed out, there is always a chance of some mishap or oversight which will result in serious injury to the operator. The danger from this source is especially great in sub-stations, where there is often only one attendant, and in case he should be injured no one is available to resuscitate him. One electric company has had three separate fatalities under these conditions during the past six years.

While it is important to keep high-tension equipment reasonably clean, it is evident that the "exposure hazard" is directly proportionate to the number of times the cleaning is done. While conditions of dust, moisture, etc., vary considerably, so that it would hardly be practicable to adopt the same practice in all plants regardless of location, it is evident that a needless hazard is assumed if the intervals between cleaning are less than a reasonable minimum.

An investigation of the conditions on a number of high-tension transmission systems shows a notable lack of uniformity in this respect, and indicates the desirability of setting some approximate standard. In one plant the cleaning was done daily, in others weekly, monthly, yearly, and in one case there was no record of the equipment having been cleaned since it was installed some two or three years previously. Obviously the first-mentioned periods were too close together, and the latter too far apart.

In an industrial sub-station, operating at 13,000 volts, where the service was severe and the conditions of dust, etc., relatively unfavorable, the cleaning process was carried on only once per month, and it was occasionally permitted to go two months without any undesirable effects being noted. This would accordingly seem to be a safe standard, and the adoption of intervals of from one to two months is, therefore, recommended.

117. **Identification**

All electrical supply equipment and circuits shall be adequately identified by position, color, number, name plate, label or design, as to voltage, intended use, and proper connections.

All connections shall be arranged in a simple and orderly manner.

SAFETY OPERATING RULES

It is probably more important to have definite written rules covering safety features to be observed in the operation of electrical equipment and lines than in any other branch of industry, since a slight mistake or oversight in connection with electrical equipment may cause instant death or serious injury. A mechanical derangement may be readily observable, but there is usually nothing in the appearance of electrical equipment to indicate whether it is alive or not, hence mistakes are more likely to occur.

The following rules, of a general nature, are reprinted from the Safety Code; detailed applications of these rules, which should be care-

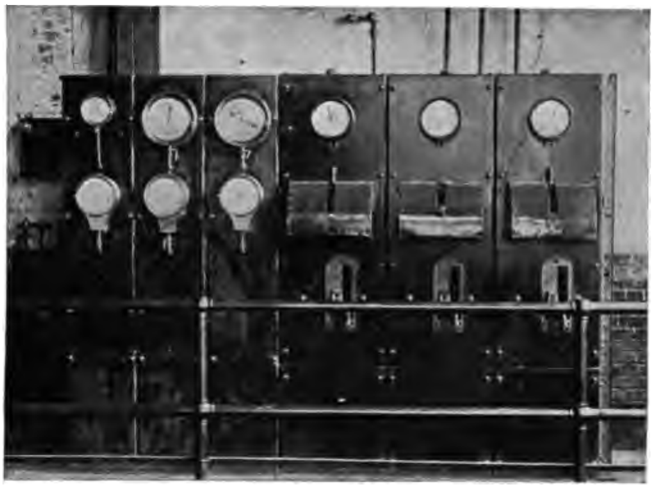


Fig. 1. Switchboard Protection.*

Fig. 2. Mill Switchboard.†

Fig. 1 shows a small power-house switchboard, located on a balcony which is equipped with a standard hand-rail, and a toe-board of woven wire. The switches are enclosed, and only the insulated handles project through the covers.

Fig. 2 shows a high-voltage mill switchboard, with grounded metal enclosure. The switch is of double-throw type, and a latch has been provided to hold it securely in the central position.

In case of electric shock, prompt attention is of vital importance. A shock may render a man unconscious so he will die if unaided, although he could be revived if some one were near to give him the necessary attention. (See "Resuscitation.")

The space back of the panels shown in Figs. 1 and 3, is enclosed and locked, and a rule is enforced that one man shall not be permitted to go back of the board alone.

Electric stations can be arranged so as to render it wholly unnecessary for the operator to approach any high-tension portion of the switchboard in his normal manipulation of the equipment. Fig. 3 shows a model sub-station installation of this kind.

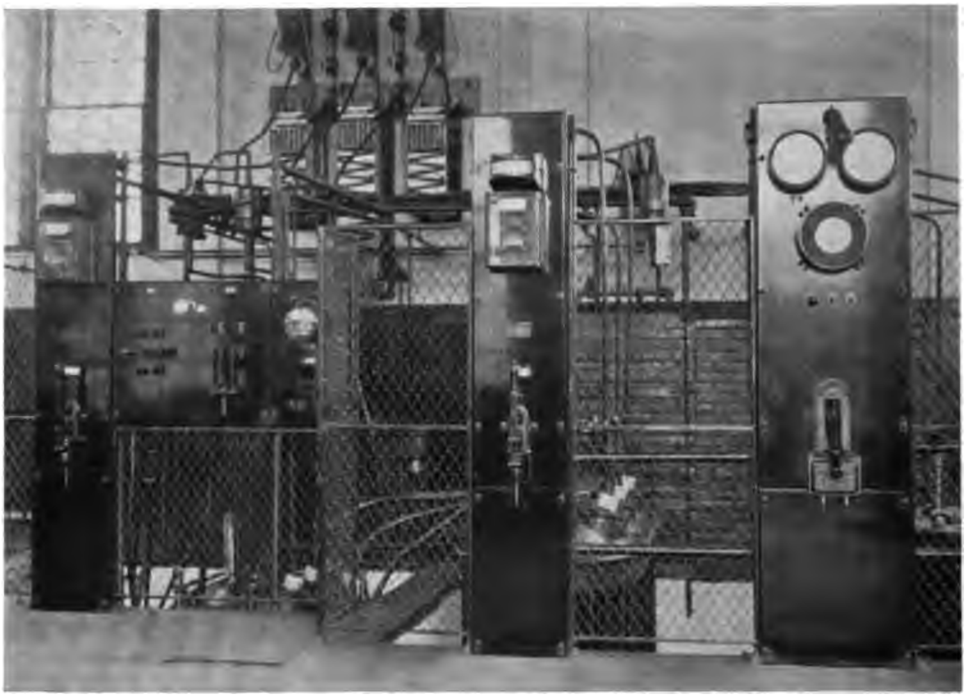


Fig. 3. Enclosure in Sub-Station.*

* Courtesy of American Steel and Wire Company. † Illinois Steel Company.

Fig. 1. Use of Messenger-Cable for High-Tension Crossing.*

Fig. 2. Safety Cage on Ladder of High-Tension Tower.*

Fig. 3. Collar on Pole.*

Fig. 1 illustrates the use of a messenger-cable for carrying high-tension transmission wires over railways, highways, etc.

This arrangement is decidedly superior to the basket construction commonly used, which is illustrated in Fig. 4. It will be evident in the latter case, that if one of the transmission wires were to break as a result of wind pressure during a storm, it might fall outside the basket, the benefit of which would thus be lost.

Fig. 2 shows high-tension towers equipped with safety cages, the bottom sections of which are solidly enclosed and locked. The ladders are offset at landings, which are 18 to 20 feet apart, so as to positively limit the distance a man could fall.

Emergency work on transmission lines is usually done under adverse weather conditions, so first-class facilities of this sort are most important.

Fig. 4. Basket for High-Tension Crossing.

Fig. 3 shows a transmission pole, equipped with a collar of barbed wire to prevent boys or other unauthorized persons from climbing it. From lack of such precautions many deaths and serious injuries have resulted.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

fully studied, are covered in wider scope in the Code.

400. **Copy of Rules**

The employer shall furnish to each employee operating or working on electrical supply equipment, power or signal lines, or electrical tests, with a copy of these safety rules for operation, and shall take suitable means to secure the employee's compliance with the same.

Many companies number their books of rules and require a receipt from each employee for his copy.

411. **Two Workmen**

Except in emergencies, at least two employees should be provided where work is done on live lines above 750 volts in wet weather or at night.

Many companies make the assignment of two men mandatory on any highly dangerous work, and some have defined closely the cases under which two men will be required. Several statutes and some commission orders also deal with the safeguarding by an additional employee. The British factory law requires that no one unaccompanied by another workman shall do any work where technical knowledge or experience is required to avoid danger.

412. **Uninstructed Workmen and Visitors**

No unqualified employee or visitor shall be allowed to approach any live parts, unless accompanied and safeguarded by a qualified employee.

413. **Diagrams for Chief Operator**

Diagrams or equivalent devices showing plainly the arrangement and location of the electrical equipment and lines should be maintained on file or in sight of the chief operator.

The diagrams for lines should show the relative position and voltage for different wire arrangement on poles or other supports on which power lines are carried, and for each crossing with other lines.

These diagrams may be of the entire system, of each specific portion of the system, or they may show typical arrangements.

414. **Instructions for Foremen**

Suitable means for identifying all equipment or lines on or near which work must be done should be supplied to the foreman locally in charge of such work.

Instructions shall describe the equipment and lines to be worked on, identifying them by position, letter, color, number, or name.

403. **Drilling Employees**

Employees working on or about equipment or lines shall be thoroughly and regularly drilled in approved methods of first aid, resuscitation, and fire extinguishment.

The drilling of employees in emergency methods, the resuscitation of persons rendered unconscious electrically, the temporary treatment of wounds and fractures, or the extinguishment of fire, are all essential to avoid panic or nervousness when emergencies arise. By actual drilling the method becomes a part of the employee's regular habit, and dependence can be placed on its being properly used when need arises. With some companies such drills are given by the various foremen, with others they are a part of the instruction given by regular instructors in the business of electrical operation.

(Author's note.) A recent death case emphasizes the necessity for the above rule. The foreman of a line gang had seen and read over illustrated rules on resuscitation which were posted by his company; yet when one of his men received a shock he was unable to recall what should be done, and a doctor, who was secured after some delay, pronounced the victim dead. There was every reason to believe that the prompt application of proper resuscitative measures might have saved his life, and without doubt the foreman could have taken such measures had he been actually drilled in their use.

404. **Posting Rules and Diagrams Permanently**

Copies of these safety rules, address list, and directions for emergencies shall be permanently kept in a conspicuous location in every station and testing room. It is recommended that they be placed also in every line wagon.

The posting of operating rules is an effective means for keeping them constantly before the workmen, so encouraging them through familiarity with the rules. In emergency even the best trained man may lose his self-possession, and instructions conspicuously posted will frequently supply the necessary fixed ideas at such times.

410. **Attendance**

A qualified employee shall be kept on duty where generators or rotary converters are operating, excepting small, low-voltage apparatus for telephone and similar work, unless the equipment is remotely controlled and its operating conditions indicated by use of pilot circuits or other suitable method at a station where an operator is located. In the latter case the generating equipment shall be made inaccessible to unauthorized persons.

415. **Protective Devices**

There shall be provided in conspicuous and suitable places in electrical stations, testing departments, and line wagons a sufficient supply of suitable protective, first-aid, and fire-extinguishing devices and equipment, to enable employees to meet the requirements of these rules. Such devices and equipment shall be periodically inspected and tested to insure that they are kept in good order. The following is a list of suitable devices and equipment, the kinds and numbers of which will depend on the requirements of each case: —

(*a*) First-aid outfits.

(*b*) Insulating wearing apparel, such as insulating gloves, sleeves, and boots.

Fig. 1. Protected Motor-Generator.*

Fig. 2. Insulated Tools.*

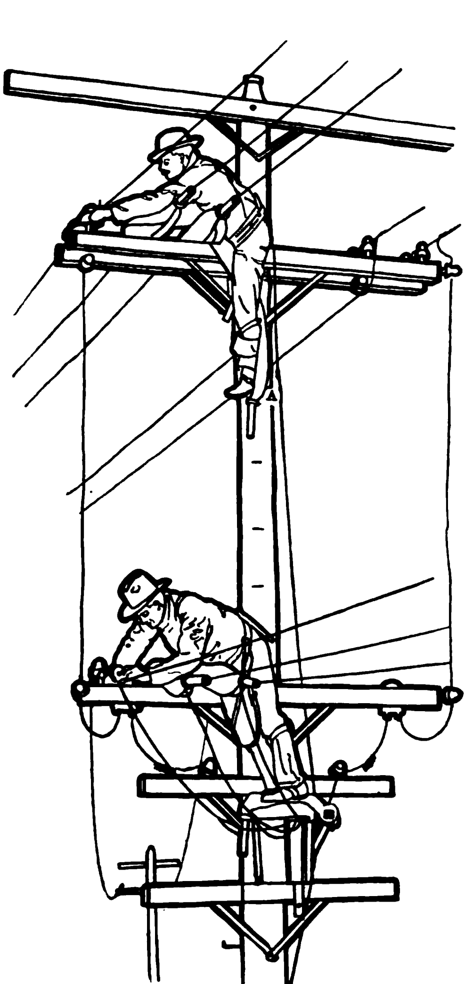


Fig. 3. Use of Linemens' Shields.

Fig. 4. Fig. 5. Fig. 6.

Vapor-Proof Globes and Snap Switch.

Fig. 1 shows steps, railings, and guards for a motor-generator set. The steps reduce danger of employees slipping, since without them it would be necessary to stand on the curved surface of the pedestal while feeling bearings, adjusting brushes, etc.

Fig. 2 shows common and insulated types of screw drivers; the use of the latter is desirable, as it may prevent flashes and burns.

Fig. 3 illustrates the use of rubber protective shields for linemen working on poles, etc.

In Figs. 4 and 5 vapor-proof globes are shown, — one arranged for conduit and the other supported by pendent wires. Fig. 6 shows a vapor-proof snap switch. Such globes and switches should be used wherever there are explosive or highly inflammable gases, dusts, etc.

* Courtesy of United Gas Improvement Company.

Insulating shields, covers, mats, stools, and platforms.
Insulating appliances, such as rods and tongs, for any necessary handling or testing of live equipment or lines.

(*c*) Protective goggles of suitable materials and construction.

(*d*) Tools of such special design and insulation as to eliminate so far as practicable the danger of forming short circuits across conducting parts at different potentials or bringing the user into circuit with such parts.

(*e*) "Men at work" tags, log books, operating diagrams or equivalent devices, and portable danger signs.

(*f*) Fire-extinguishing covers and appliances, either designed for safe use on live parts, or plainly marked that they must not be so used.

(*g*) Grounding devices for making protective grounds.

The above devices shall be kept, when not in use, in their regular location and in good working order.

Safety belts, whether furnished by employer or employee, should be inspected periodically to assure their safety.

416. **Warning and Danger Signs**

There shall be displayed in conspicuous places at all unattended or unlocked entrances to electrical supply stations and testing rooms or rooms containing exposed live or moving parts permanent warning signs forbidding entrance to unauthorized persons.

Suitable danger signs shall be placed in power stations and testing rooms about equipment having exposed current carrying parts above 750 volts.

423. **Supervision of Workmen**

Workmen whose employment incidentally brings them in the neighborhood of electrical supply equipment or lines, with the dangers of which they are not familiar, shall proceed with their work only when authorized. They shall be accompanied by a properly qualified and authorized person, whose instructions must be strictly obeyed.

Though a man may be experienced for his own particular class of work, as, for instance, a painter, carpenter, etc., he may be quite ignorant of the danger in approaching the live parts of electrical equipment and lines with which he is inexperienced. The regular station attendant and the lineman may approach such parts with comparative safety. It is, therefore, advisable for men without the special experience which will safeguard them about electrical equipment to be under the direct supervision of an experienced and properly qualified person while in such locations.

425. **Live and Arcing Parts**

(*a*) ***Treat Everything as Alive.*** — Electrical equipment and lines should always be considered as alive unless they are positively known to be dead. Before starting to work preliminary inspection or test should always be made to determine what conditions exist.

(*b*) ***Protection Against Arcs.*** — If exposed to arcing, the hands should be protected by insulating gloves, and the eyes by suitable goggles or other means.

Employees should keep all parts of their bodies as distant as possible from brushes, commutators, switches, circuit breakers, or other parts at which arcing can occur during operation or handling.

426. **Safety Appliances and Suitable Clothing**

(*a*) ***Safety Appliances.*** — Employees at work on or near live parts should use the protective devices and the special tools provided, first examining them to make sure that these devices and tools are suitable and in good condition. Protective devices may get out of order or be unsuited to the work in hand.

(*b*) ***Suitable Clothing.*** — Employees should wear suitable clothing while working on or about live equipment and lines. In particular, they should keep sleeves down and avoid wearing unnecessary metal articles, celluloid collars, celluloid or metal cap visors, or similar articles. Near live or moving parts loose clothing and shoes that slip easily on floors worked upon should not be worn.

427. **Safe Supports and Safety Belts**

(*a*) ***Safe Supports.*** — Employees should not support themselves on any portion of a tree, pole structure, scaffold, ladder, or other elevated structure without first making sure that the supports are strong enough, reinforcing them if necessary.

Portable ladders should be in a safe position before being climbed. The slipping of a ladder at either end should be carefully guarded against, especially where the surfaces are smooth or vibrating.

(*b*) ***Safety Belts.*** — Employees should not work in elevated positions unless secured from falling by an approved safety belt or by other adequate means.

428. **Repeat Messages**

To avoid misunderstandings and to prevent accidents, each person receiving an unwritten message concerning the handling of lines and equipment shall immediately repeat it back to the sender and secure his full name and acknowledgment. Each person sending an unwritten message shall require it to be repeated back to him by the receiver and secure the latter's full name.

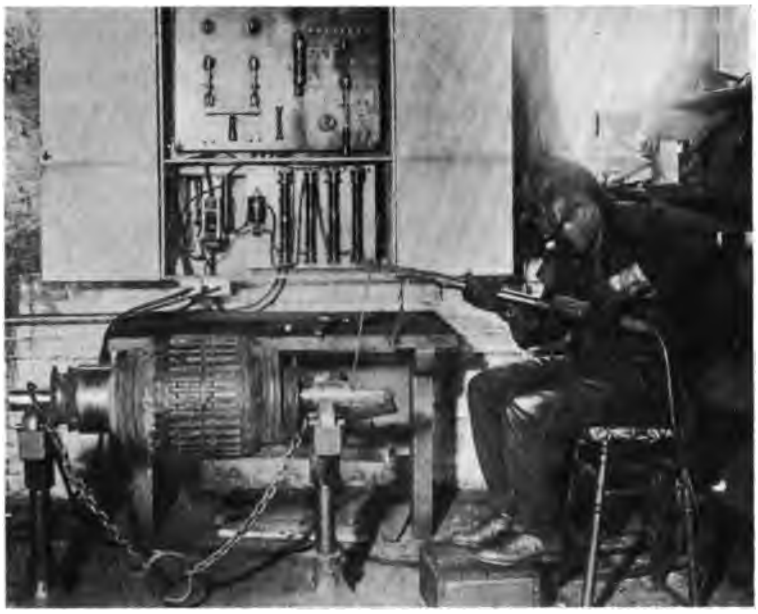


Fig. 1. Automatic Switch controlled by Spring Button in Handle, to safeguard Electric Welder.*

Fig. 2. Separation of High-Tension Bus-Compartments into Circuit-Groups.*

In Fig. 1 the switch cuts off current automatically when pressure of thumb is released.

A physical separation between adjoining circuits (Fig. 2) is desirable and may prevent serious accidents caused by persons mistaking phases of different circuits for those of the same circuit.

Fig. 3. Isolation or Enclosure of Motor located in Work-Room.†

Fig. 4. Remote Control Equipment in High-Tension Station.‡

In Fig. 3 the motor is located in a locked enclosure, making it inaccessible to unauthorized persons.

Remote control systems (Fig. 4) enable the operator to manipulate high tension electrical equipment from a safe distance, through grounded secondary circuits of low voltage and capacity.

* Courtesy of Boston Elevated Railway Co. † Courtesy of Remington Typewriter Works.
‡ Courtesy of Stone and Webster Engineering Corporation.

Many accidents are due to misinterpretation of instructions or information, and the practice of repetition of unwritten messages is widely practiced to avoid misunderstandings of this kind.

The regulations of some companies require that both parties make a written record of telephone messages, which are later preserved for references.

435. **Tagging Electrical Supply Circuits**

Before work is done on or about any equipment or lines used as transmission or interconnected feeder lines, or lines operating above 7500 volts, or lines killed at stations or sub-stations to protect workmen, the chief operator shall have "Men at work" tags attached at all points where such equipment or lines can be manually controlled by regular operators, to plainly identify the circuits worked on.

Before work is done on or about any equipment or lines which are killed by the foreman in charge of the work, at points other than stations, the foreman shall have "Men at work" tags placed at all points where the circuit has been disconnected, to identify the portion worked on.

(Methods to be followed in killing supply equipment, lines and moving parts are covered in sections 45 and 46 of the Safety Code.)

CHAPTER 14

POWER CONTROL, — QUICK-STOPPING DEVICES, ETC.

THE principal sources of power in use at the present time are Steam, Electricity, Water, and Gas. It is fortunate that electricity is coming into more and more general use as a medium for driving machinery, since it lends itself most readily to the application of safety measures.

With electric motors the application of power is so nearly continuous as to practically eliminate the necessity for fly-wheels. This means that when power has been shut off, the machinery will come to a stop much more quickly than is the case with engines having large fly-wheels, the momentum of which keeps them running for some time after the throttle-valve is closed. Where particularly rapid stopping is desired, it can often be secured advantageously by means of dynamic braking, if electric power is used.

Electricity is usually applied in the form of individual or group drives. This brings the controlling device close to the place where power is used, and it can thus be reached promptly in case of accident. The use of group drives also makes practicable the shutting down of shafting while repairs, adjustments, etc., are being made, without interfering with the operation of many machines.

A further advantage of individual or small group drives is the elimination of long lines of transmission shafting, belting, etc., in connection with which there is always danger from breakage. The oiling and attention necessary for the proper maintenance of shafting is also hazardous, and many vertical belts interfere with the light to a considerable extent.

The other sources of power mentioned, viz., steam, gas, and water, are about on a par as regards safety features; each one has certain elements of hazard peculiar to itself, and they are all more difficult to control in case of emergency than electricity.

QUICK-STOPPING DEVICES

In most accidents where men are caught in machinery, it is of vital importance to shut off the power immediately. It is not sufficient to have belt shifters or clutches for the individual machines only, since accidents on smooth transmission shafting are of relatively frequent occurrence. (See Page 142.) In such cases, the seriousness of the injury is likely to be in direct proportion to the time that elapses before the shafting can be stopped. It is accordingly most important for the safety of employees that means be provided on each floor, and in each room, for shutting off the power supply to that room and stopping all shafting and countershafting in it without delay. Such an arrangement may also be of value in preventing property loss when a belt or shaft breaks.

Several types of quick-stopping devices, adapted to various kinds of service, will be described, including Automatic Engine Stops, Quick-closing Valves, Clutches, Tight and Loose Pulleys.

Automatic Engine Stops. The best arrangement for shutting down a steam engine in case of emergency is the "Automatic Engine Stop" (Fig. 1, P. 131). This consists of a valve in the main steam line to the engine, usually closed by an electro-mechanical tripping device, the latter being operated by a series of electric push-buttons distributed at convenient points throughout the plant. Provision for independent mechanical operation of the valve may or may not be combined with the electrical operation. In conjunction with the system of push-button control an auxiliary speed limit is commonly applied, which affords an additional precaution against over-speeding. (See Fig. 2, P. 131.)

The advantages of an Automatic Engine Stop are: — (1) the engine may be shut down directly by a man at the scene of an accident, without any other human intermediary, and (2) the possibility of a fly-wheel explosion is considerably reduced, due to the automatic speed limit.

The disadvantages of the Engine Stop as compared with friction clutches, motor stops, etc., mentioned later, are: — (1) the momentum of the fly-wheel is sufficient to keep an engine running for some time after the steam has been cut off (say from 15 seconds to one and a half minutes, under ordinary conditions, depending on the load), and (2) stopping the prime-mover in a large establishment interferes with the work of all departments, where it might be sufficient to merely cut off power from the particular department affected.

A good Automatic Engine-Stop system should comply with the following requirements: —

Operating current. Where the operation of the system is dependent on electric current, it is most important to have a continuous and thoroughly reliable source of current supply. For this purpose secondary or storage batteries are preferable, provided a suitable charging circuit is available. Ordinary dry cells should never be used, on account of their liability to fail at a critical time. A case in point may be cited, where a serious fly-wheel accident occurred on an engine equipped with an automatic stop. When the engine raced, due to a gear in the governor mechanism breaking, both the automatic speed limit and the push-button circuit failed to respond on account of dry-cell battery exhaustion, although the engine had been shut down a few hours previously by this system.

Storage batteries may be provided in duplicate, so that one set will be in service while the other is being charged; if a single battery is used, it should "float" on the line, being charged constantly at a sufficiently low rate to avoid injury from over-charging. Where alternating current only is obtainable, it is necessary to have it converted or rectified before it can be used for charging batteries.

Storage batteries should be installed in well ventilated cabinets or other suitable enclosures, which will protect them from mechanical injury. The cells should preferably have glass bodies in order to facilitate inspection, and they should be observed at intervals to see that the liquid does not become too low through evaporation. Where practicable, it is well to take periodical hydrometer readings of the liquid, to see that proper density is being maintained.

Primary batteries. Where no electric circuit is available for charging storage batteries, it may be necessary to use primary cells. These should be of the highest grade (such as Burn-Boston or Sampson no. 3 for open-circuit systems, and Edison-Lalande or Columbia Track for closed-circuit systems) and special care should be taken to see that they are renewed before undue exhaustion or deterioration has occurred.

Open-circuit cells should have an initial strength of 20 to 25 amperes on short-circuit, and should be discarded when the ampere reading has dropped to 10. There should be a sufficient number of cells to give an ample factor of safety in operating the most remote button and overcoming the electrical and mechanical resistance of the system, when the amperage has been reduced to this minimum limit.

A suitable ammeter should be provided, preferably attached permanently to the switchboard. For open-circuit systems the ammeter should be arranged so that the battery can be short-circuited through it and a reading taken, by merely operating a button or switch. For closed-circuit systems the ammeter should be permanently connected in the battery circuit, so it will constantly indicate whether the battery is charging, floating, or discharging. With this arrangement a meter having "centre zero" scale is required.

Owing to the fact that the discharge from batteries on open circuit is relatively infrequent, occurring only when an emergency shut-down of the engine is being made or when the system is being tested, the batteries do not deteriorate very rapidly. In order to prolong the battery life, however, it is possible to use current from an ordinary mill supply of 110 or 220 volts, with

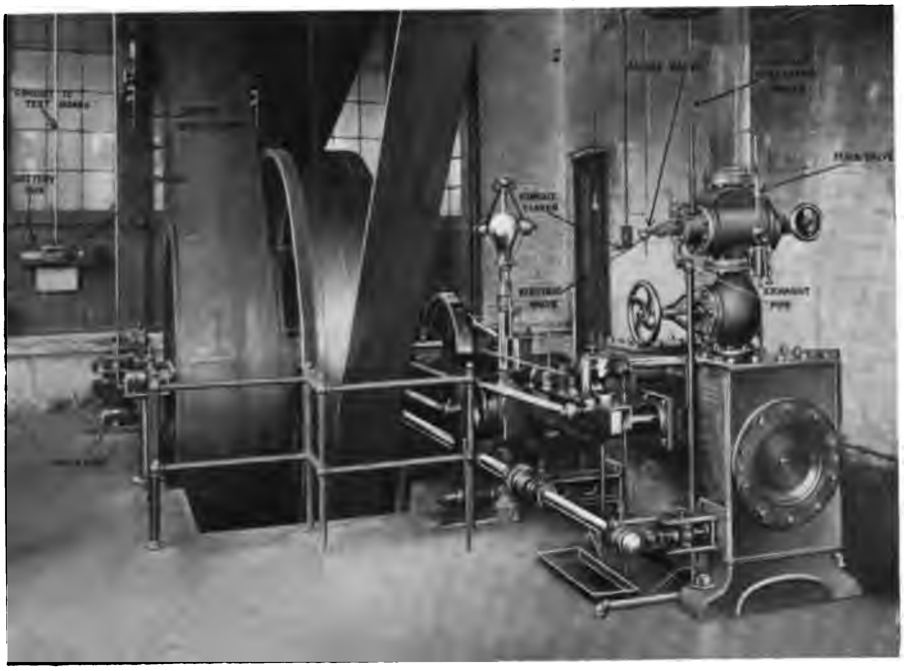


Fig. 1. Automatic Engine-Stop Installation.

Fig. 2. Speed Limit with Rope Drive.

Fig. 1 shows the various parts which compose one of the standard Automatic Engine-Stop systems, viz: — Main Valve (independent type), Speed Limit, Test Board, and Storage Battery. The wiring is protected by metal conduit.

The notice in Fig. 3 is used in a large plant, in which every minute's shut-down involves heavy loss. Note also break-glass button and hammer, constantly burning blue light, blue band around post and sign.

Fig. 3. Engine-Stop Station.*

Fig. 4. Test-Board with Enclosed Indicator.

This prevents tampering with the adjustment. Switches for testing continuity of lines, etc.; push-button for stopping the engine; automatic switch for running on generator current (upper position) and throwing over by gravity to battery circuit if generator current should fail, are also shown.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

an automatic solenoid switch which will throw over by gravity on to the battery circuit in case the regular supply fails or is shut off for any reason. (See Fig. 4, Page 131.)

Type of circuit, — "open" or "closed." Where a constant current supply is assured, and the stations are few in number and not widely separated, it may be desirable to have the push-buttons arranged on a closed-circuit system. This means that failure of the current supply or derangement of the wiring will be made known by the automatic shutting-down of the engine.

It will be evident, however, that when the engine is stopped from such causes, one of two alternatives must be followed, — the engine must be kept at a standstill until the trouble can be corrected, or it must be started with the engine stop out of commission.

Either of these alternatives is undesirable. The first may involve a shut-down of several hours, and incident loss of time and production before the cause of failure can be located and removed; this is particularly liable to occur in large establishments where an extensive system of wiring is necessary. If the second alternative is adopted and the engine is started immediately, a serious accident may occur before the stop can be put in operating condition again.

These difficulties make the open-circuit system preferable, at least for large installations and where there are facilities for charging storage batteries. It is possible, by a proper installation and system of testing, to reduce the chance of failure with an open-circuit system to a point where it is negligible. For such systems the following arrangement should be adopted:

Each wire of the push-button circuit should be "looped," or returned independently to the switchboard, and both ends should be connected to a common terminal, provision being made, however, for testing the wires independently in series, for breaks. With this arrangement, either or both wires of the main circuit may be broken at any one point, without interfering with the action of any button. It is apparent that the chance of breaking a wire at two separate points, between tests, is very slight.

Type of valve. Combined throttle and automatic-stop valves are manufactured, but where a new valve is purchased for an engine-stop system, it should be preferably of independent type (Fig. 1, P. 131). This arrangement leaves the existing throttle valve available for the use of the engineer without any complications. It has the additional advantage of giving two stop-valves in the steam connection; if one should leak or become defective, a second would be available to stop the flow of steam.

Wiring should be run in conduit, at least on walls or in other places where it may be exposed to mechanical injury. The installation should comply with the requirements of the National Electrical Code.

Push-buttons used in an engine-stop system should be high-grade, and of a type which is so enclosed as to be thoroughly dustproof. This enclosure is particularly important where the buttons are exposed to dampness or vapors which might cause corrosion, and thus interfere with a proper completion of the circuit when the button is pushed.

Sometimes complaint is made, where engine stops are used, that unauthorized persons push the buttons and shut down the engine without cause. This can be avoided by the use of a "break-glass" button similar to those commonly used in fire-alarm systems. A small hammer should hang beside such buttons for promptly breaking the glass. (See Fig. 3, P. 131.) Buttons should be conveniently located, at points not more than 50′ distant from any machinery driven by the engine they control. They should be so marked as to be readily distinguishable.

Speed limits should be driven from the engine by ropes (preferably three in number), rather than by belts (Fig. 2, P. 131). Ropes are superior for this service on account of the fact that there is no danger of their slipping as a belt may do if it becomes oily; also because the ropes can be replaced one at a time as they show signs of wear, thus avoiding the danger of sudden failure which results from a breaking belt.

Vacuum breakers. Where engines run condensing, it is desirable to have a vacuum

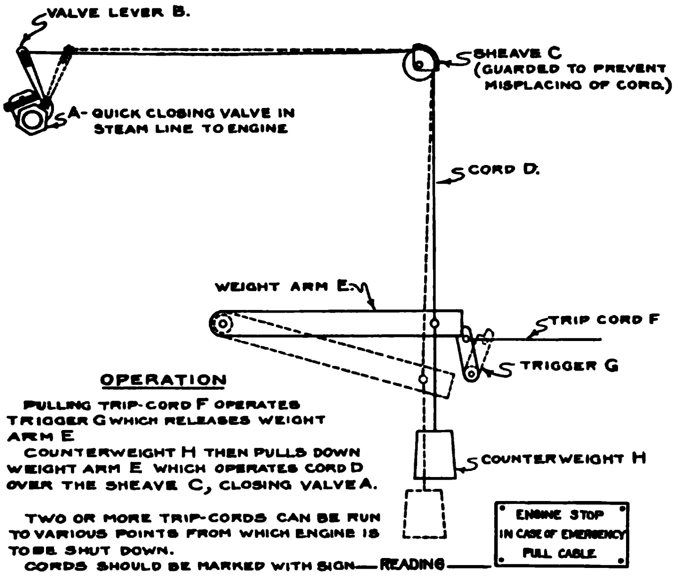


Fig. 1. Quick-Closing Lever Valve with Counterweight and Trip Cord.

Fig. 2. Quick-Closing Piston Valve with Mechanical Trip.

These illustrations show devices for shutting down engines from a distance, suitable for small installations. They are satisfactory for use where the space covered is not too great, and where the Speed Limit which goes with the Automatic Engine Stop is not essential. The arrangement shown in Fig. 1 can also be utilized for throwing out friction clutches.

Fig. 3. Butterfly Valve with Counterweight and Trip Cords.*

Fig. 4. Electric Controlling Device for Water Wheel.

Butterfly valves, as shown in Fig. 3, may be quickly closed in case of emergency to prevent an engine from racing. They cannot be depended upon, however, to stop the engine, as they are not entirely steam tight.

Electric stops can also be applied to the control of water wheels, as illustrated in Fig. 4.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

breaker, to facilitate prompt stopping. Such devices can be obtained with electric operation, and connected into the wiring system in such a manner that the vacuum will be broken automatically whenever the engine stop is operated.

Inspection and testing. It is of vital importance that a systematic arrangement be made for the periodical testing of this equipment. The daily shut-downs should be by means of push-buttons, preferably by the use of a different button for each successive shut-down.

At least once per week the entire system should be tested out, including battery reading, speed limit, main wires, and individual push-buttons. This may be done without interfering with the engine operation by having some one at the main valve to re-set it each time a button is pushed, the batteries being numbered and a record of the numbers being kept so as to make sure that all of the buttons are operated. It is well to have the weekly tests reported in writing and checked up independently by some competent person, thus making sure they will not be neglected.

"Quick-Closing" Valves. A simple mechanically operated valve of quick-closing type may be used also for shutting down steam engines. Such valves may be operated either by direct mechanical means, or through a tripping device which is released from distant points by pulling a cord or pushing an electric button. (See Page 133.)

They are somewhat less expensive than the regular Automatic Engine Stops, and may be used advantageously for small engines where the steam line is, say 6″ or less in size, and where only a few stations are required. For large and important installations, one of the regular Automatic Engine Stops with Speed Limit is to be preferred, since it offers a more complete and comprehensive system of protection.

Quick-closing valves used for this purpose should be of piston, poppet, or some equally positive type, which can be depended upon to shut off steam entirely when they are operated. "Butterfly" valves are not satisfactory for this service, since it is impossible to make them absolutely steam-tight.

A butterfly valve may be used as a precaution against the engine's racing, since it operates quickly and will reduce the flow of steam to a small amount. Even for this service, however, it may prove ineffective unless carefully inspected and tested at frequent intervals to see that it is in proper working condition. Out of several cases which have come to the author's attention, two may be cited by way of illustrating unsatisfactory results from butterfly-valve installations.

In one case an electric unit of approximately 500 K.W. capacity, would carry a load of 75 K.W. with the butterfly valve shut. In another case, when the engine raced and the engineer tried to close the butterfly valve, it stuck so that he could not operate it; he then ran to the throttle valve and had it almost closed when the fly-wheel burst.

Clutches. Clutches, or clutch pulleys, furnish an effective means for stopping shafting in separate rooms or departments supplied from a common source of power. For this service the clutches should be of friction or magnetic type, so they can be thrown out readily. It is possible to carry cords from the operating lever of a friction clutch to different points in a room or building, from which the clutch can be manipulated. Where a magnetic clutch, or a counter-weighted friction clutch with solenoid tripping device, is used, electric push-buttons may be employed for its control. The use of a clutch in this manner gives a desirable quick-stopping device, since it is not necessary to overcome the momentum of the engine fly-wheel before the shafting stops revolving.* (See Pages 133 and 135.)

* If a single friction clutch is arranged so as to control the entire engine load or a large portion of it, care should be taken to see that the engine governor is adequate to check the sudden increase in speed which will result when the clutch is thrown out. This makes an unusual demand on the governor, and may result in wrecking the engine if the governor does not operate satisfactorily. Under these conditions it is particularly desirable to have a "Low Plane Governor Stop," or other automatic speed limiting device, so that entire dependence will not be placed on the governor to prevent the engine from racing.

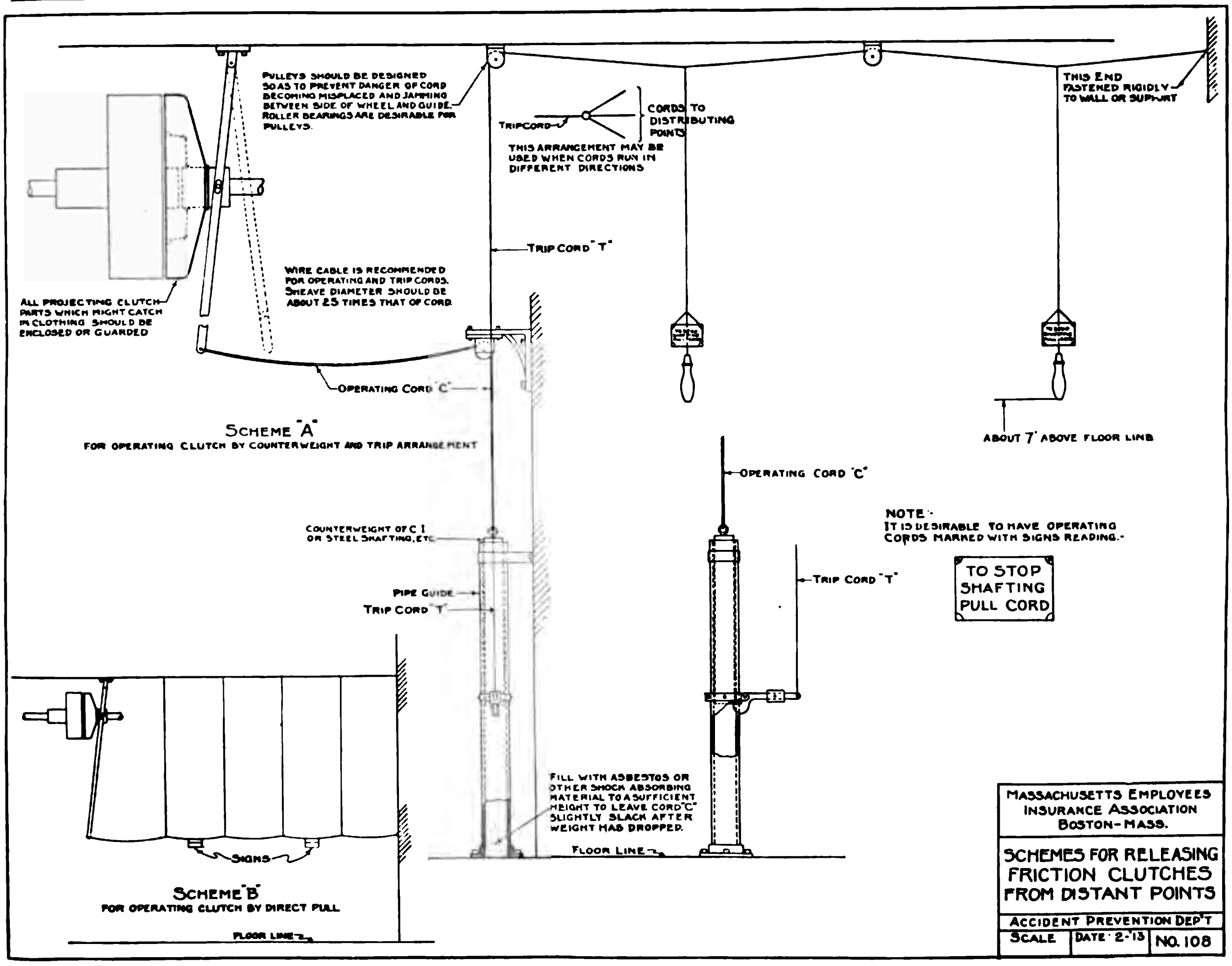


Fig. 1. Clutch-Operating Arrangements.

Fig. 2.

Fig. 3.

Fig. 4.

The illustrations on this page show various methods for releasing clutches from a distance. In Fig. 1 a trip cord and counterweight are used. In Figs. 2 and 4 devices are shown which may be operated either mechanically or electrically. Fig. 3 shows the use of a trip cord on a clutch.

Tight and loose pulleys. Where power is supplied to a room or building by a main belt, it may be possible to install a belt shifter, and a loose pulley to which the belt can be shifted, thus stopping all shafting in the room.

If the room is small, the shifter itself may furnish sufficient facilities for emergency stops. Where the room is large, various means may be provided to facilitate the shutting off of power, such as a cord attached to the shifter and carried to convenient points throughout the room; where it is not satisfactory to have this cord work directly on the shifter, the latter may be counterweighted or provided with a spring tending to shift it to the loose pulley, with a suitable catch for releasing it on which the cord operates. (See Fig. 1, P. 133.)

Such an arrangement is quite satisfactory where the belts are not too large. The limit may be placed at about six or seven inches in width; for larger sizes than that, it is difficult to shift a belt readily.

In this connection it is worth mentioning that safety requirements are not met satisfactorily where provision is made for merely throwing off the main driving belt, unless there is some suitable arrangement for returning it to the tight pulley again. Where the belt is thrown entirely off the pulley, without such arrangement, and must be replaced by hand in starting up, there is a material element of hazard in replacing the belt. Serious accidents have occurred from this cause. (See Fig. 2, P. 162.)

Belt tighteners. Where there is a belt tightener or "idler" it can sometimes be utilized as a means of emergency power control. A counterweight can be arranged to throw out the idler and stop the belt, the counterweight being released by a catch and trip-cord.

Motor Stops

Where the machines are driven individually or in small groups, the power control is readily taken care of through the provision of a single switch for shutting off the current.

Where machines in any one group are located on different floors, or where the groups are so large that the main switch cannot be reached within a short distance (say 25 to 50 feet) from each machine controlled, it is important that some further stopping facilities be provided. These facilities may take the form of additional switches in the main power circuit, or of auxiliary control circuits working on some suitable form of circuit-breaker or magnetic switch. This auxiliary circuit should have switches or push-buttons located at points convenient to the machines served, so they can be operated instantly in case of accident. (See Page 111.)

Another very simple and effective method of providing stopping facilities in such cases, is furnished by the use of a cord or cable attached directly to the main switch, and arranged so that the latter will be thrown out by a pull on the cord. This cord can then be carried to points near the machine operators or other employees.

In some respects, a cord arranged in this way is superior to switches or buttons, in that it can be used instantly from any point along its length, by merely catching or striking it; this does not require the careful attention necessary for operating a button or switch, which can only be reached at a given point. It is also simpler, mechanically, and less liable to get out of order than an electric circuit. (See Page 137.)

In all cases these stopping devices, whether switch, push-button, or cord, should be clearly marked with a sign permanently kept in place, reading somewhat as follows: "Motor Stop, in case of Emergency, push button (pull cord, etc.)"

From the standpoint of quickly stopping the machinery, there is an element of value in large groups; the total load on the motor is heavier and more likely to be on at a given time, so the machinery will come to rest more quickly after the power is cut off than if the groups are small. On the other hand, a large group has the disadvantage of making it impossible to shut off the power for repairs and adjustments without losing the product of many machines.

Miscellaneous Arrangements. Distant control through the medium of electric push-buttons or other devices on the order of those already described may also be provided for shutting

Fig. 1. Stop-Cord for Rubber Rolls.*

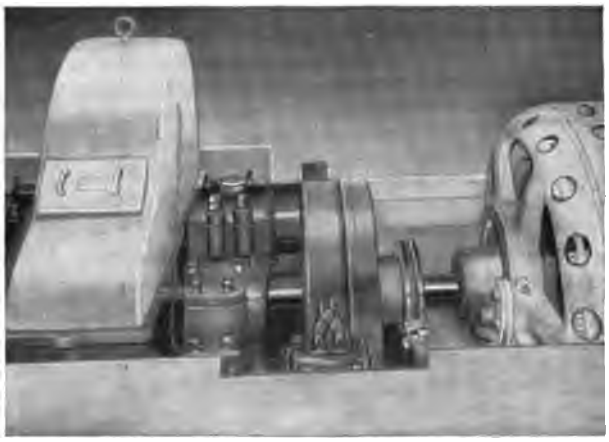


Fig. 2. Magnetic Clutch and Brake.

These illustrations show emergency stopping devices applied to rubber-mixing machines and calenders. If any one should be caught in the rolls (Fig. 1), a slight pull on the safety rope would throw out the main switch and stop the motor. Such ropes should be so low that a man who was caught could operate them by striking the rope with his head or body.

It is desirable to have some kind of braking arrangement, to check the momentum of moving parts which might otherwise draw a man into the rolls after the power has been cut off. Fig. 2 shows a magnetic clutch, used in conjunction with a band brake (Fig. 3) which is applied automatically whenever the clutch is thrown out. Tests on a mill equipped in this manner showed a peripheral roll travel of only about 2″ after the stop was operated, compared with 51.9″ without the brake.

Fig. 3. Magnetic Brake.

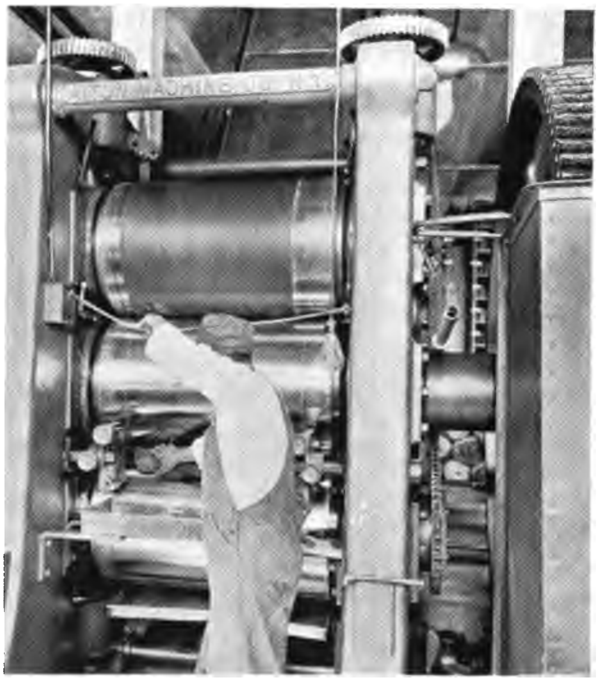


Fig. 4. Stop-Cord for Calender.*

Where the equipment is motor-driven, dynamic braking may often be employed for emergency stops.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

down water wheels, gas engines, steam turbines, etc. (See Fig. 4, P. 133). Push-buttons can be readily utilized for short-circuiting the ignition current of gas engines having electric ignition, thus quickly stopping them.

LOCKING POWER CONTROL

Unless the equipment driven from a given source of power is immediately adjacent to, and within sight of, the power-controlling device, the latter should be arranged so it can be locked in the "off" position. This is for the protection of men who might be injured by the accidental or unexpected starting of the machinery.

It is often necessary for millwrights, inspec tors, repairmen, etc., to work while the machinery is shut down, in positions where death or serious injury might result if the machinery should be started before they are through. In such cases the time of the ordinary daily shutdowns is commonly utilized. Unless the work is of a very limited character, so there is no question but that it can be completed before the time to start the machinery has arrived, the power-control device should be locked.

It is always a wise plan to lock the control switch where electric power is concerned, on account of the facility with which a switch may be thrown in and the machinery started. The danger of engines being started at other than the regular time is not great, since the engine is ordinarily controlled by one man, and if the unit be large there is more or less complication in starting it. A motor switch, however, may be thrown in at any time by some unauthorized person, through ignorance, curiosity, or other reasons, unless it is locked.

For engine drives the valve wheel lock shown in Fig. 3, P. 79, furnishes a satisfactory device. This can also be applied to the control wheel of steam or water turbines. Where electric power is used, the control switch should be provided with some form of effective locking device. (See Page 115.)

Various other arrangements, such as lock and chain, may be used for different types of equipment, to suit the form of control in question. While the locking device is in use, the man for whose protection it is being employed should preferably keep the key, in order to avoid any possibility of misunderstanding.

CHAPTER 15

PROTECTION OF POWER TRANSMISSION EQUIPMENT

SHAFTINGS, PULLEYS, COUPLINGS, SET SCREWS, ETC.

THE elimination from revolving shafting, pulleys, and couplings, of all projecting parts which might catch in the clothing, such as set screws, bolt-heads and keys, is of primary importance. These parts should be countersunk or covered so as to render them safe. (See Pages 140 and 141.) Unused portions of keyways should be filled in such a manner as to present a perfectly smooth surface. (See Page 289.)

A smooth revolving shaft also may catch and wind up clothing which comes in contact with it. Where such shafting is within reach from the floor or customary working positions of operators, it should be enclosed or protected by suitable barriers. (See Pages 142 and 328.)

In ordinary work-rooms, the following standards for the protection of exposed shafting are recommended: —

Vertical and Inclined Shafts to be encased to a height of 6′ from the floor, or provided with a standard railing on unprotected sides, located at least 15″ horizontally from centre line of shaft.

Horizontal Shafting, not more than 6′ above floors, platforms, etc., to be encased, or protected on all exposed sides by a standard railing. Such railings should preferably be located at least 15″ horizontally from shaft. If less than this at any point, the railing should be solidly sheeted over at such point.

Projecting shaft ends 2″ or more in length, and located not more than 6′ above floors, platforms, etc., to be cut off, equipped with protective cups or casings, or provided with guards as specified for shafting.

There are many places, however, where additional precautions are needed, as for example, in stock or storage rooms where the material is piled to a considerable height. Such conditions may bring an employee into contact with shafting high above the floor, and it should accordingly be completely enclosed in these locations. (See Page 142.)

It is also a good plan to eliminate or guard projecting shaft ends, even though they are located more than 6′ above the floor or platform level. Guards for this purpose may consist of (1) a cup around the end of the shaft, supported by brackets (as illustrated for coupling guard, Fig. 6, Page 141), or (2) a board or steel plate carried down vertically from the ceiling past the end of the shaft.

Footwalks along lines of shafting, for the use of oilers, repairmen, etc., are of doubtful value. In some instances, facilities of this sort have been responsible for accidents; they afford such easy access to the shafting that employees are prone to work on it while it is running. Where such walks are provided, they should either be locked up and a rule enforced preventing their use while the shafting is in motion, or persons on the walks should be thoroughly protected from accidental contact with the shafting, belts and pulleys, etc.

BELTING

The hazard from belting varies with the power transmitted, — in other words, — with the size and speed of the belt. While there is obviously no definite point at which the hazard of a small belt ceases to exist, the following standards are recommended as representing good practice in the protection of transmission belts: —

Belts (and Pulleys) more than seven feet above floors, platforms, etc. All overhead belts seven inches or more in width, running thirty feet or more per second, shall be protected in one of the following alternative manners: —

(1) A suitable guard shall be placed immediately underneath the belt; this guard shall be of

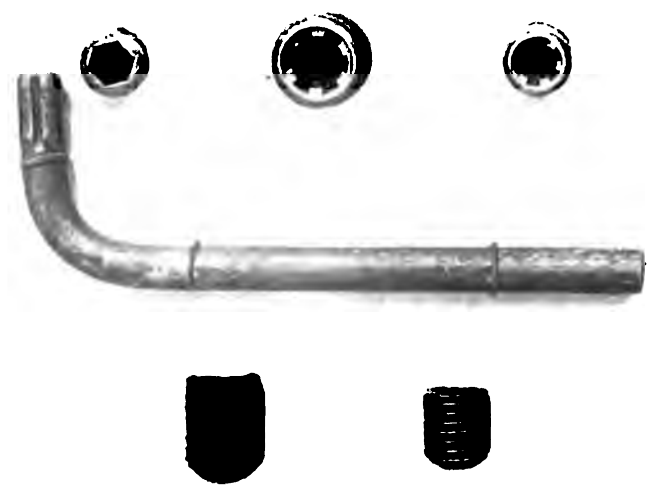


Fig. 1. Types of Safety Set Screws.*

Fig. 2. Safety Collar.*

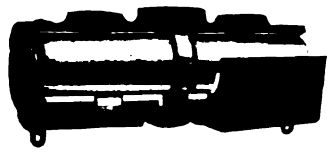


Fig. 3. Collar concealed in Bearing.

Many serious and fatal accidents have resulted from the use of projecting set screws in revolving shafting or machinery parts, and the hazard from this source is now generally recognized. Projecting screws should be eliminated entirely from such equipment; this may be done by countersinking the ordinary set screw as shown in Fig. 4, or by replacing the projecting screw with a hollow one, different types of which are shown in Fig. 1.

To have adequate strength, hollow screws should be machined from solid stock, and there should be sufficient thickness of metal at the point to prevent their "giving" or loosening up while in service.

Sometimes a second safety screw can be placed on top of the first, thus locking the latter securely in position.

Safety collars, having sufficient depth of stock to safely permit the use of the ordinary square-headed screw, are shown in Figs. 2 and 4.

An excellent arrangement is to have thrust collars concealed in bearings, as shown in Fig. 3, thus entirely eliminating the necessity for screws outside where men may come in contact with them.

Sometimes projecting set screws are covered, but this may permit accidents through the removal of the cover, and the best plan is to do away entirely with projecting screws.

Fig. 4. Countersunk Set Screw.*

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Coupling with Cover.

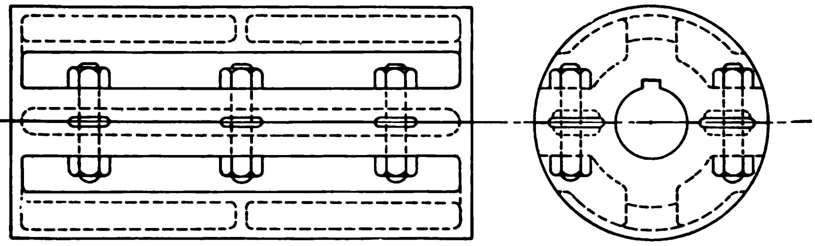


Fig. 2. Coupling with Shield Cast Integral.

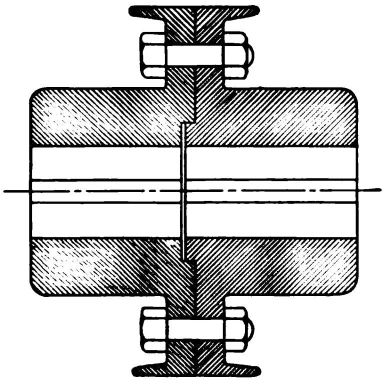


Fig. 3. Coupling with Safety Flange.

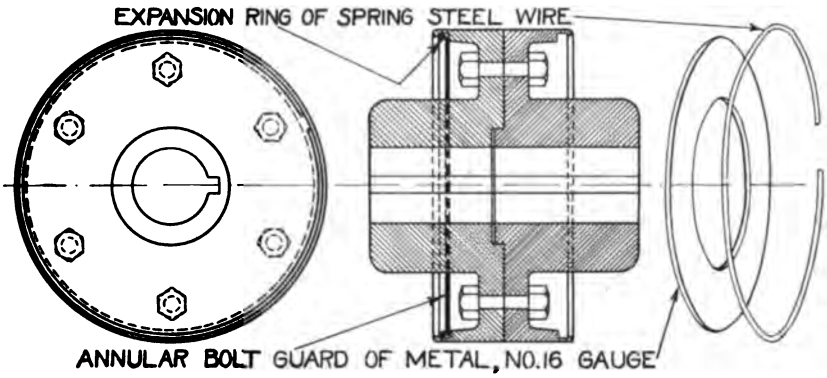


Fig. 4. Coupling with Safety Flange and Disc Shield secured by Wire Snap-Ring.*

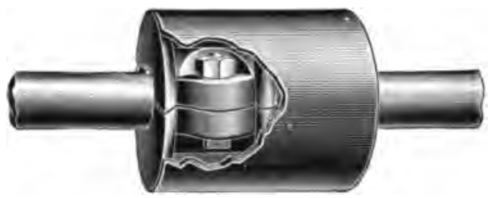


Fig. 5. Coupling with Tubular Shield.

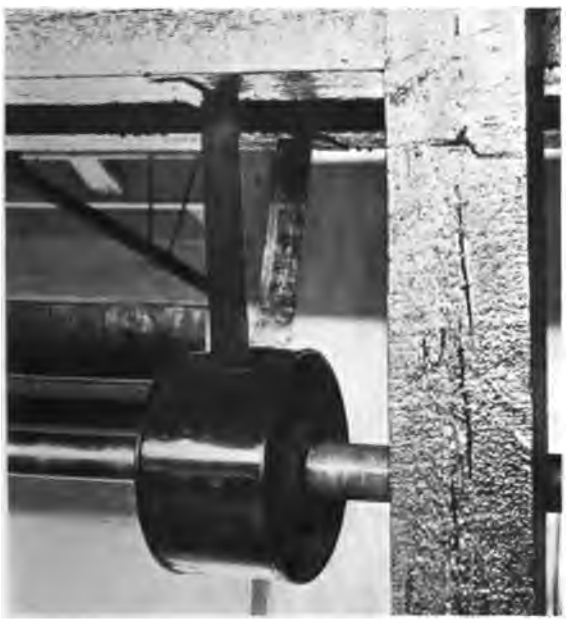


Fig. 6. Guard for Couplings already in Place.

Figs. 1 to 5 show various types of protected couplings.

Where couplings with safety flanges (Fig. 3) are used, it is important to see that the bolt-ends do not project beyond the flange.

Fig. 4 shows an ingenious device for insuring safe conditions in this respect. Bolts of proper length must be used, or the shield cannot be put in place. The latter, when in position, thoroughly guards the bolts.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

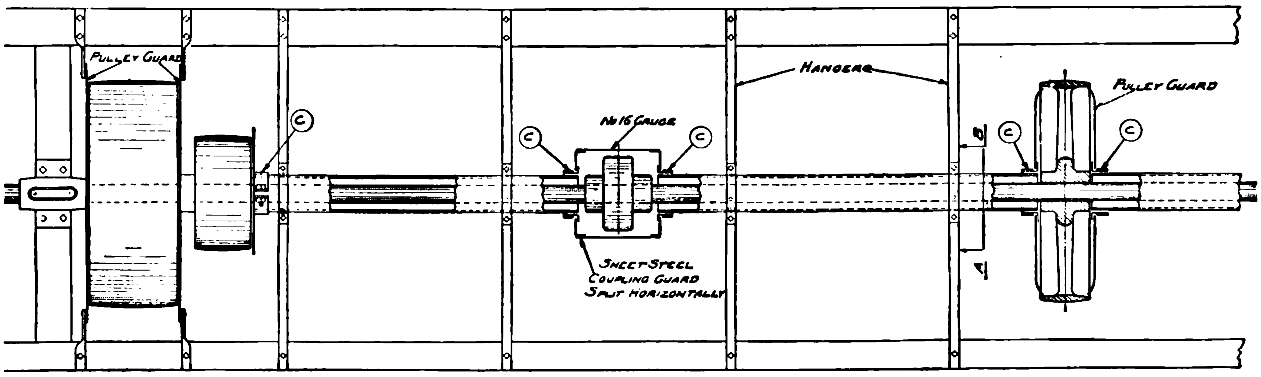


Fig. 1. Fatal Shaft Accident.

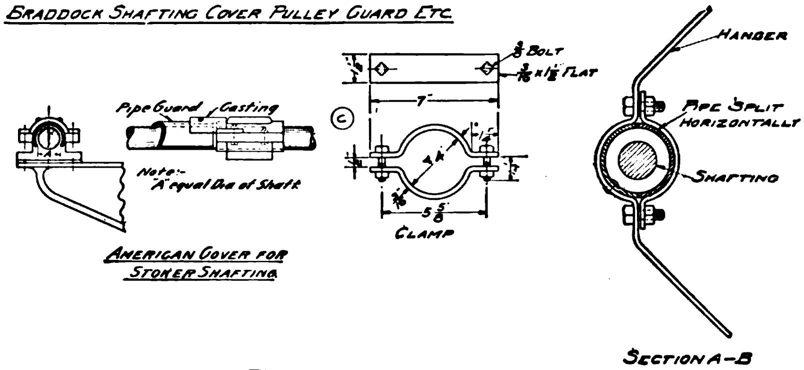


Fig. 3. Methods of Guarding Shafting.†

This resulted from a man's clothing being caught on this smooth shaft, while he was standing astride it attempting to replace belt on pulley.

Tubes which rest on the shaft and revolve with it may be used also for this purpose.

Fig. 4. Guard for Shafting.† (See "American Cover for Stoker Shafting," Fig. 3.)

Fig. 2. Fatal Accident on Shaft End.*

In working at manhole shown in Fig. 4, persons may come in contact with the revolving shaft. Such shafting should be enclosed.

The shaft shown in Fig. 2, which projected 14″ beyond its present length, caught the clothing of a workman and he was killed.

* Courtesy Minnesota Bureau of Labor, Industries, and Commerce.

† Courtesy American Steel and Wire Company, subsidiary of the United States Steel Corporation.

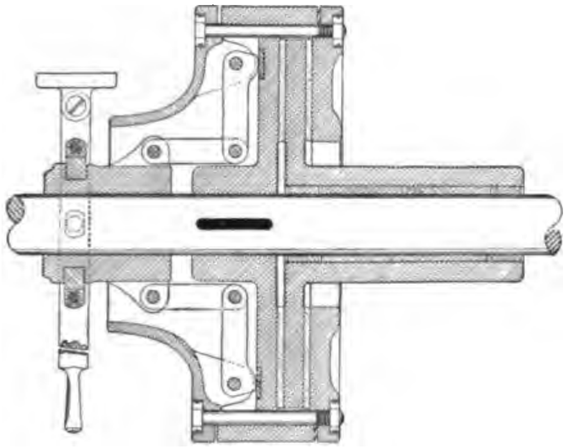


Fig. 1. Clutch with Shield over Projecting Parts.

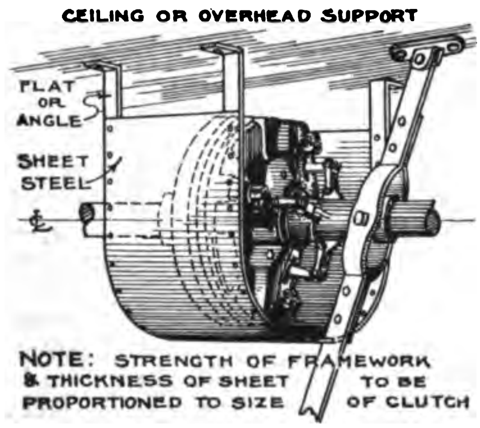


Fig. 2. Guard for Clutches already in Place.

Friction clutches, as commonly constructed, have set screws and other projecting parts upon which clothing of workmen may catch and cause injuries. Figs. 1, 4, and 5 show provisions made by some of the standard clutch builders for protecting their equipment. Where such guards are specified at the time an order is placed, they can be furnished with the clutch, at the minimum expense.

Fig. 3. Clutches, Guarded and Unguarded.*

Fig. 4. Sheave with Protected Clutch.

Fig. 5. Pulley with Protected Clutch.

Figs. 2 and 3 illustrate satisfactory guards for clutches already in place which need special protection. In one case the guard is fastened to an independent support; in the other it is attached to the clutch lever. Fig. 3 shows several guards in position on the clutches, and one removed to illustrate clearly the method of attachment.

* Courtesy of Eastman Kodak Company.

substantial construction, securely fastened in place and carried up around pulley receiving downward travel of belt to ceiling, beam, or other support, in order to prevent a breaking belt from catching on end of guard. (See Fig. 1, Page 145.)

(2) Floor space underneath belt, included within the following dimensions, to be railed off or otherwise blocked against passage, — railed space to extend 15″ beyond belt at both sides and at the ends to extend beyond either pulley to a point where a line 45° from the vertical projected from center of pulley would touch the floor; this space not to be used for storage or other purposes. (See Fig. 2, Page 145.)

Belts (and Pulleys) seven feet or less above floors, platforms, etc. Such belts shall be guarded in accordance with standards outlined for protection of individual machines. (See Page 160.)

Passageways through belts. Where there is space between upper and lower parts of a belt which may be used for passage, a substantial passageway, completely enclosed on sides exposed to breaking belt, and on top (also at bottom if belt is exposed there), shall be constructed (see Figs. 3 and 4, Page 145); otherwise such space shall be completely barred against passage.

Rope Drives. Ropes and sheaves to have same protection as belts and pulleys, except that all enclosures must be of solid construction, or sheeted over, in order to prevent a breaking rope from tangling around exposed railings.

Removing Belts from Overhead Pulleys.

For removing belts from overhead pulleys a straight pole with a spike or spur in the end is recommended. Where there are wooden ceilings or beams above the shafting, the spike may have a pointed end which can be pressed into the ceiling or beam, the belt being thrown off by a lateral movement of the lower end of the pole.

In some instances, where the shafting is carried by steel and concrete supports only, sockets have been provided in which the end of a pole could be placed to throw a belt from the pulley.

Replacing Belts on Overhead Pulleys

The practice of replacing belts on overhead pulleys while the shafting is running is an essentially hazardous one. (See Fig. 2, Page 162.) Many serious accidents have occurred from this practice, and it should never be attempted by any but a thoroughly experienced and competent mechanic. Where a pole is used, there is danger of its being caught between the belt and pulley, or of its striking the arms of the pulley, thus being thrown violently and injuring the person using it or others who may be nearby. Where the attempt is made to throw the belt on by hand, the person may be caught between the belt and pulley or entangled in the belt and drawn around the shaft.

Probably the safest plan, and one that is recommend for use wherever practicable, is to tie the belt lightly to the pulley while it is shut down, in such a manner that the belt will run on to the pulley when the latter starts, without being touched by hand. The shafting is then started slowly, and stopped (if necessary) to remove the fastening after the belt is safely on the pulley.

Obviously this plan is impracticable where the shafting is driven at a considerable distance from the place where the belt must be applied, and where many machines would be shut down by stopping the shafting to replace a belt. Under such conditions a belt pole may be used. A good form of pole is shown in Fig. 3, Page 146. The action of this pole is similar to that of shifting the belt from a loose to a tight pulley, and its construction is such as to minimize danger of injuries from the pole being struck by the arms of the pulley.

Where belt poles are used they should be of sufficient length to extend well beyond the body of the person using them. This permits the lower end of the pole to be "steadied" against the body, and obviates danger of the pole being driven into the body in case it should strike an overhead pulley.

Belt Perches. It is desirable to have suitable "perches" provided for supporting individual belts when they are thrown off the machines. If such a belt is left in contact with the running shaft, it is liable to catch and pull down the shafting, or cause other accidents. Belt perches have an element of economy, aside from their

Fig. 1. Guard for Overhead Belt.*

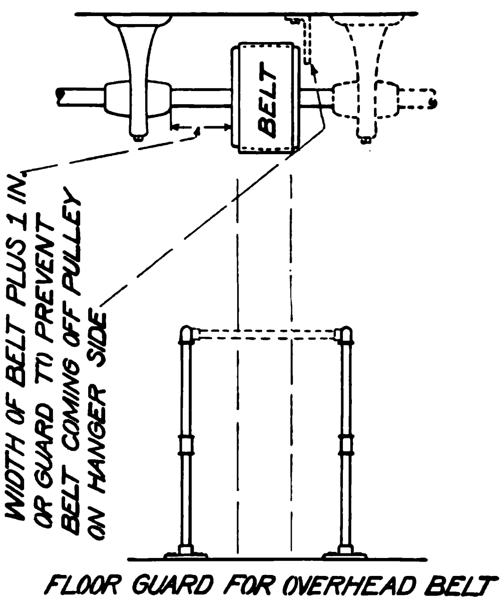


Fig. 2.

Various forms of guards for main belts are shown on this page.

The guard illustrated in Fig. 1 has a hinged door in the end which may be opened to facilitate the replacement of a belt. Doors are provided in the enclosure shown in Figs. 3 and 4, through which the bearings may be oiled and inspected.

Such guards must be strongly constructed and securely fastened in place, to prevent their being wrecked by a breaking belt.

Fig. 2 shows a floor guard, which may be used instead of the overhead guard illustrated in Fig. 1.

Fig. 3. Passageway at End of Main Belt, protected by Concrete Pier and Overhead Channels.†

Fig. 4. Passageway under Main Belt, protected by Arch of Reinforced Steel Plate.†

* Courtesy of United Shoe Machinery Company.
† Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

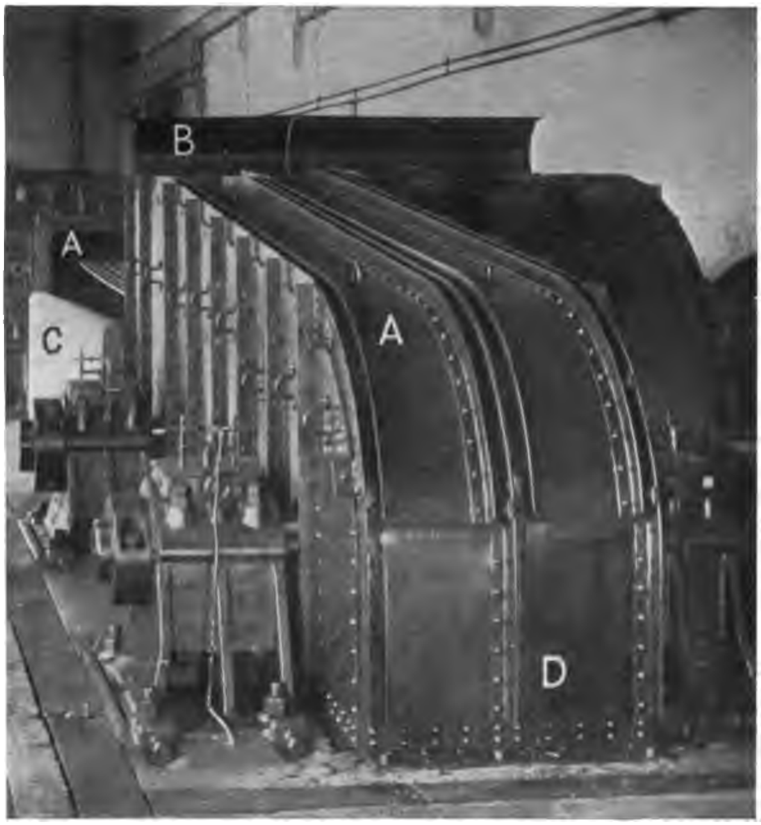


Fig. 1. Guarded Rope Drive. (Courtesy of National Tube Co.)*

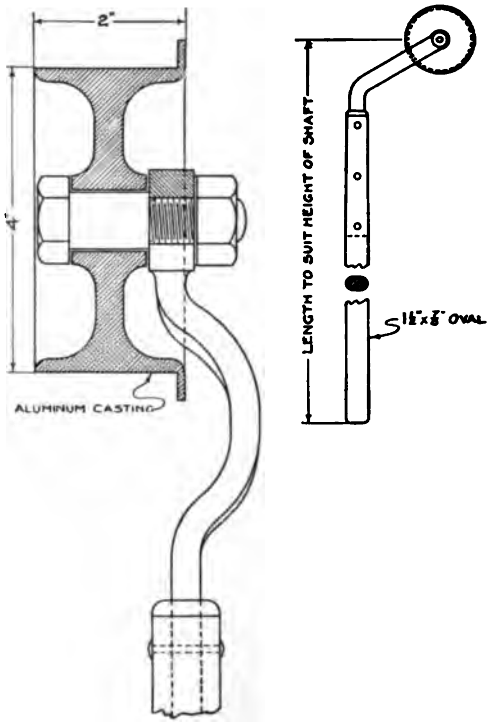


Fig. 3. Belt Pole. (Pat.)

The action of this pole (Fig. 3), in replacing a belt, is similar to that of shifting a belt from a loose to a tight pulley.

Where rope drives are used there is danger of a breaking rope causing a wreck, on account of one end winding around the shaft and the other becoming entangled in adjacent machinery. The guards shown in Fig. 1 have a curved plate (B) to prevent ropes whipping around edge of guard, and the enclosure is made up in sections which can be readily removed when making repairs.

Fig. 2 illustrates guards for rope drive and sheave at engine. Attention is directed to the manner in which the guard is extended in height at the side of sheave, to protect any one oiling or inspecting the main bearing. This is a point which is frequently neglected in connection with guards for engine-sheaves or fly-wheels.

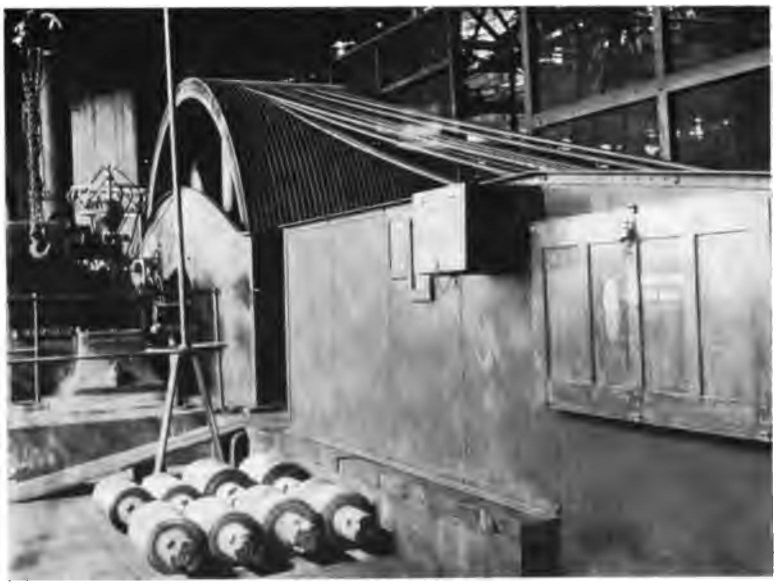


Fig. 2. Guarded Rope Drive. (Courtesy of American Steel and Wire Co.)*

* Subsidiary of United States Steel Corporation.

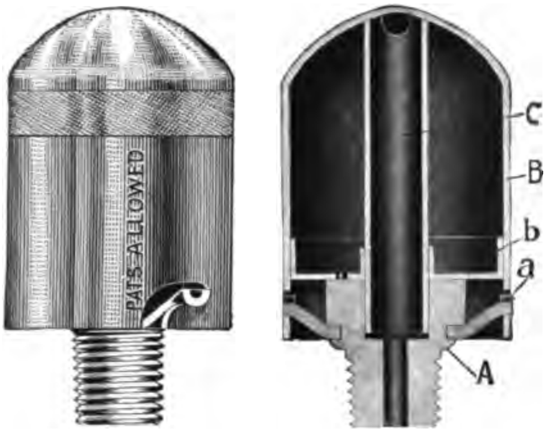


Fig. 1. Fig. 2.
Oil Cup for Loose Pulley.

Fig. 5. Guard for Bolts of Split Pulley.*

Fig. 3. (Patented.)

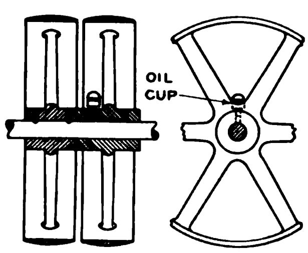


Fig. 4.

Fig. 6.

Loose pulleys on overhead countershafts, etc., are commonly oiled while the machinery is running, on account of the fact that it is necessary to turn the pulley around by hand, so the oil-hole can be reached. This necessitates the belt being on the tight pulley.

The danger from oiling with power on is obvious. A good method of overcoming the difficulty is to use an oil cup such as that illustrated in Figs. 1-4. The cup, which is attached to the hub of the pulley, is filled with ordinary machine oil through stem C, Fig. 2. It will be noted by Fig. 2 that when the pulley is at rest the oil cannot escape, and when it is running, centrifugal force prevents oil from flowing down the stem. A few drops of oil reach the bearing, however, each time the pulley is stopped or started. The oil cup need only be filled about once a week, and this can be done when the machinery is shut down, regardless of position of pulley.

Fig. 6 illustrates complete enclosure of a pulley, to protect the spokes.

The use of belt perch (Fig. 7) is advantageous from the safety standpoint as well as that of wear and tear on the belts.

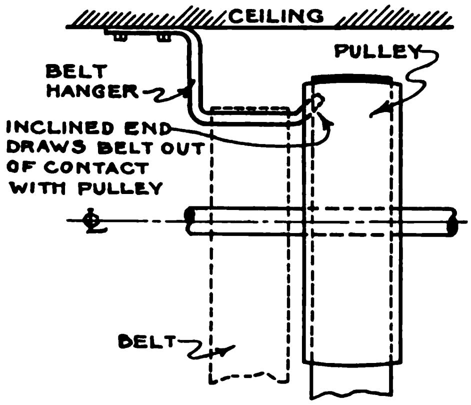


Fig. 7. Belt Perch.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Long-Spout Oil Can.*

Fig. 2. Bearing equipped with Oil Cup.*

Fig. 1 illustrates the use of a long-spout oil can by means of which the bearings of overhead shafting can be lubricated from the floor. The use of this device practically eliminates the hazard of oiling, which is one of the dangerous occupations of an industrial plant. In oiling by means of a ladder, the oiler may be caught on the shafting or in belts and pulleys, or he may fall from or with the ladder.

Where a long-spout can is used, it requires only a fractional part of the time needed to oil a line of shafting by the old method, wherein the oiler ascends and descends a portable ladder at each bearing. The economy of the oiler's time which results is a material consideration in favor of the long-spout can, in addition to the improved safety conditions.

As it is sometimes difficult to locate the small oil-hole in an ordinary bearing from the floor, the use of a special oil cup, as illustrated in Figs. 2 and 3, has been found advantageous. The hinged lid of this cup can be quickly thrown back by the spout of the can, and the glass body shows the level of oil in the bearing, where ring oiling bearings are used. The latter are to be preferred to plain bearings, since they require much less attention.

The use of an oil cup, as described above, improves lubricating conditions, since it keeps dust out of the bearing, thus preventing wear and saving the bearing.

Fig. 3. Glass-Bodied Oil Cup with Hinged Lid.*

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

value in avoiding accidents, since they prevent needless wear and tear on the belts. (See Fig. 7, Page 147.)

Clearance from Hangers. Pulleys should be preferably spaced far enough from hangers (and from other pulleys) to allow adequate clearance if the belt should drop off on the hanger (or pulley) side. Where this arrangement is impracticable, a guard which will prevent such an occurrence should be placed at the side of the pulley. (See Fig. 2, Page 145.)

GEARING

.The gearing on main power transmission equipment should be enclosed or guarded as specified for gearing on machines. (See Page 166.)

LUBRICATION OF BEARINGS, ETC.

The lubrication of bearings on overhead shafting, and of loose pulleys on countershafts, etc., is an important matter from the safety standpoint. The use of self-oiling bearings with oil reservoirs of sufficient capacity to operate for several weeks without re-filling is advantageous, since this reduces the number of times the shafting must be oiled.

Facilities for oiling shafting from the floor are illustrated and described on Page 148.

An excellent device for lubricating loose pulleys is shown on Page 147, Figs. 1, 2, and 3.

CHAPTER 16

CAST IRON AND STEEL

THESE materials, — more especially steel, — enter into so many important uses which have a direct bearing on the accident problem that some knowledge of their special characteristics is of value to any one interested in accident prevention.

The following brief discussion of various phases of the subject which particularly affect human safety, is given in the belief that it will be helpful to safety inspectors and others who are endeavoring to prevent industrial accidents.

CAST IRON

The facility with which iron castings can be made, and their relatively low cost, have resulted in the adoption of this material for a wide range of uses. The extreme variation in the tensile strength of cast iron, however, together with its brittleness, makes it undesirable for any service where it will be subjected to high tensile stresses, shocks, etc. It was formerly employed considerably in the construction of high-pressure boiler parts, steam fittings, etc., as a result of which a number of serious accidents have occurred. The Massachusetts Boiler Rules specifically forbid a pressure of more than twenty-five pounds per square inch in a boiler constructed wholly of cast iron, or a pressure of more than one hundred and sixty pounds per square inch in a boiler, the tubes of which are secured to cast-iron headers. In ordering new equipment it is desirable to eliminate cast iron entirely from parts subjected to high steam pressures.

Cast iron is still used quite generally, however, for steam heated rolls in laundries, paper and textile plants, as well as for hot plates of various kinds. For such service extreme care should be taken to see that perfect castings are secured, free from blow-holes, slag, cold-shuts, or other defects, and a high factor of safety (not less than 10) should be adopted. Where steam is taken from high-pressure boilers, a suitable reducing valve in conjunction with a safety or automatic stop valve, should be installed to properly limit the pressure. (See Fig. 1, P. 79.)

The results of eight consecutive tensile tests of cast iron used in making high-grade drying cylinders are given below. These tests were made on bars $\frac{5}{8}''$ in diameter; nos. 3 and 6 were cast to this size, the others being cast $\frac{3}{4}''$ diameter and turned down to $\frac{5}{8}''$.

No. 1.	33,100 lbs. per sq. in.		No. 5.	35,800 lbs. per sq. in.
" 2.	30,900 " " " "		" 6.	37,400 " " " "
" 3.	26,100 " " " "		" 7.	20,100 " " " "
" 4.	32,400 " " " "		" 8.	26,700 " " " "

No. 3 was found to have been weakened by a $\frac{1}{8}''$ blow-hole and No. 7 by a $\frac{1}{4}''$ blow-hole. While the entire list indicates high-grade material, it also brings out the wide variation in the strength of iron castings. This variation has resulted in the adoption of 16,000 to 18,000 pounds per square inch as the safe rated strength of cast iron, and this rating is recommended for use in calculating the strength of equipment such as that mentioned above.*

STEEL

Steel castings have a tensile strength of approximately three times that of cast iron; for this reason steel can often be substituted for cast iron to advantage in service affecting human safety. Rolled or forged steel, being more homogeneous and less liable to local de-

* It should be remembered that, in general, large sections fail at a lower unit stress than small ones; a large casting is more likely to be weakened by local defects, shrinkage strains, etc. The small test-piece cannot, therefore, be taken as a positive indication of the strength of the cylinder or other large casting, and would generally indicate a higher tensile strength than could be reasonably expected in the latter.

fects, is superior to steel castings, and should be used so far as practicable in preference to the latter.

Specifications for Chemical and Physical Properties of Steel

The necessity for having proper specifications for the chemical composition and physical characteristics of steel is now too well recognized to need special comment. The use of the microscope and micro-photographic outfit affords an additional valuable means for accurately determining these characteristics. (See "The Metallography of Iron and Steel," Sauveur.)

Such specifications vary according to the use which is to be made of the steel, and information along these lines can be obtained from standard reference works.* For certain kinds of service which are of special interest to the safety inspector, such as hoisting chains and hooks, bolts under steam pressure, hooks and supports for swinging scaffolds, etc., the specifications commonly used for rivet steel may be adopted, namely, —

Manganese .... .30%–.50%
Sulphur not to exceed .... .045%
Phosphorus not to exceed .... .04%
Carbon not to exceed .... .10%
Tensile strength of standard 8″ test piece, 45,000 to 55,000 lbs. per square inch.
Yield point in lbs. per square inch, not less than one-half tensile strength.
Elongation in 8″, min., per cent $\frac{1,500,000}{\text{Tens. Str.}}$ but not to exceed 30%.
Test piece (not exceeding $\frac{3}{4}$″ in thickness) to stand cold bending and quench bending 180° flat on itself without cracking on the outside of the bent portion. (For the latter test the specimen is heated to a light cherry red and quenched in water, the temperature of which is from 80° to 90° F.)

The bending test can be applied readily to specimens of bolts, etc., and furnishes a simple and reliable method for the indication of brittleness resulting from crystallization or other causes. Where a microscopic examination is to be made, it is well to nick the specimen on both sides to a depth of about one-sixteenth of an inch before bending it, so that it will break without undue distortion of the structure. An examination of this kind is desirable for indicating the homogeneity of the piece, and should reveal imperfections such as seams, cavities, particles of slag, etc.

* Detailed specifications for steel to be used in various kinds of service have been standardized by the American Society for Testing Materials. Information on these standards may be obtained from the reports and Proceedings of the Society.

"**Crystallization**" is a term which has been popularly used to describe a coarse-grained structure in steel. This structure makes the steel brittle so that it readily gives way under torsional or bending strains, although the tensile strength of the steel may not be seriously affected.

It is commonly supposed that this formation is caused by shocks or stresses which occur during service. When a bolt, chain, or other mechanical contrivance gives way and the fracture shows this coarse-grained structure, "crystallization" furnishes an easy explanation of the trouble and one which is usually allowed to pass unchallenged.

Within the past few years, however, a careful study of this subject has been made, particularly by various committees and members of the American Society for Testing Materials, and the causes which determine the structure of steel are now quite well defined and rules for controlling it have been determined.

It has been shown conclusively that the coarse-grained structure can develop only while the metal is hot, and that it cannot be brought about under ordinary service conditions while the metal is cold. In other words, — when a broken part which has not been subjected to high temperature in service shows the effect of crystallization, it indicates that the part received improper heat treatment during the process of manufacture or annealing. The coarse-grained structure existed at the time the part was placed in service and was merely revealed by the breakage.

While this formation can only take place within certain temperature ranges, there are other factors which affect it, notably the chemical composition of the steel, and whether or not the part has been critically stressed while cold. The rapidity of heating and cooling also affects the structure.

There is a range of critical stresses (which may be caused either by tension or by compression), which results in the ready formation of crystalline growth when low-carbon steel is heated to a temperature of about 650° C. for a given length of time.* Stresses of an intensity greater or less than the critical stress do not affect the structure one way or the other at any ordinary temperatures used in annealing. (Figs. 1 and 2, P. 153.)

There is a certain range of temperatures within which the coarse-grained structure is refined, and which should be secured to give proper annealing. Temperatures below or above this range tend to increase the crystallization, and therefore affect the material adversely.

Proper annealing will refine the structure and correct the faults arising from improper heat treatment or critical stressing of the material (unless the adverse treatment has been so severe as to actually crack or break down the physical structure of the metal, which, of course, annealing treatment will not correct).

The American Society for Testing Materials publishes the following list of annealing temperatures for steel containing not more than 0.75% of manganese. (See "Practice recommended for annealing miscellaneous rolled and forged carbon-steel objects," Vol. 11,—1911,— or "The Metallography of Iron and Steel," Sauveur, Lesson XII.)

Range of Carbon Contents	*Annealing Temperatures*
Less than 0.12%	875° to 925° C. (1607° – 1697° F.)
0.12 to 0.29%	840° to 870° C. (1544° – 1598° F.)
0.30 to 0.49%	815° to 840° C. (1499° – 1544° F.)
0.50 to 1.00%	790° to 815° C. (1454° – 1499° F.)

The following points are also emphasized in this report: —

Since the proper annealing temperature covers a comparatively small range, it is desirable to have a reliable pyrometer, the accuracy of which is frequently checked, to determine this temperature. It is also essential to see that the heat is practically uniform throughout the object which is being annealed, so that the outer portion will not be too hot or the inner portion too cool to give the desired results. It is suggested that the final application of heat preceding the annealing temperature be gradual, so as to allow time for the necessary diffusion.

After the annealing temperature has been held long enough to make sure that it is uniform, the rate of cooling should be regulated in accordance with the amount of carbon present, namely, — the higher the carbon the slower should be the cooling, the slower the cooling the softer and more ductile the metal will be, and the lower its tensile strength, elastic limit and yield point. The greatest strength and elastic limit can only be obtained at the sacrifice of softness, ductility, and resistance to lateral and torsional stresses.

Articles containing more than 0.50% carbon should cool slowly until the color dies away, say 500° C. (932° F.). Proper cooling may be accomplished by leaving them in the furnace until this temperature is reached; they may then be removed and cooled in the air. Thin objects containing 0.25% to 0.50% carbon should be similarly treated, unless handled in such quantities that the mass will retard their cooling. Objects containing less than 0.50% carbon may be cooled merely in air after removal from the furnace, although they should be protected from snow or rain and heavy draughts.

Where special annealing is performed for removing the effects of rolling or working cold or at low temperatures, it is recommended that the object be heated to about 775° C. (1427° F.) and cooled with slowness which should increase with the thickness (i.e., least dimension) of the piece. Thin plates may be heated to merely 725° C. (1337° F.) and cooled slowly. For thick forgings sufficient time should

* See "Notes on Crystalline Growth of Ferrite below its Thermal Critical Range," by Albert Sauveur, Proceedings International Association for Testing Materials, New York, 1912, — or "The Metallography of Iron and Steel," Sauveur Lesson XII.

Fig. 1. Steel Bar, 0.05 Carbon, Magnified Three Diameters.*

Fig. 2. Steel Section, 0.05 Carbon, Magnified Six Diameters.*

Fig. 3. Incipient Cracks at Base of Threads.†

Figs. 1 and 2 illustrate the effect of critical stressing in facilitating crystalline growth in low-carbon steel. The bar (Fig. 1) was strained by bending, and the other section (Fig. 2) by having a steel ball pressed into its upper surface. Both pieces were heated to 650° C. for seven hours, and show a field of critical strain (defined by Prof. Sauveur at about 40,000 lbs. per square inch for this material) where decided grain growth or "crystallization" resulted.

The portion of the material on either side of the crystallized part was strained either too much or too little to cause crystallization.

Fig. 3 shows incipient cracks in a threaded rod or bolt. Such cracks are likely to increase progressively, under successive stresses, until complete failure results.

Fig. 4 shows an imperfection in a piece of steel, from which a progressive fracture is liable to start.

Fig. 4. Imperfection (probably from Particle of Slag) in Broken Eye-bolt.†

* From "The Metallography of Iron and Steel," Sauveur.

† Courtesy of Watertown Arsenal.

be allowed to relieve severe stresses, — the temperature of 775° C. being prolonged for several hours.

If the steel contains less than 0.15% carbon, it should be annealed at 900° C. (1652° F.). Great brittleness may be caused by annealing very low carbon steel in the neighborhood of 700° C. (1292° F.) after cold working.

In an article on "Structure of Steel" in the 1911 volume of the Proceedings of the American Society for Testing Materials (page 325), Mr. Howe mentions a case where steel when wire drawn would stand considerable bending, but after heating at 650° C. became so brittle that it broke when dropped to the ground.

In this same article Mr. Howe makes the following statements relative to low carbon steel, — 0.12% or less: —

> "Coarseness produced at 600° to 770° C.
> Between 700° C. and 895° C., —
> (a) If initially fine-grained coarsens slowly.
> (b) If initially coarse-grained refines slowly, to coarsen again on long exposure."

In other words, it may be properly annealed at the temperature range already given in the table but re-coarsens if held at higher temperatures.

The heat treatment of steel is a complex subject, and there are many variable quantities, but the foregoing paragraphs give an outline of the important principles involved.

Their meaning to the Safety Inspector is this: — Wherever steel is used in any form where breakage may result in personal injuries or loss of human life, it is of great importance to make sure that the steel has received the proper heat treatment.

This applies to hooks and chains used for hoisting, hooks for swinging scaffolds, brake-rods, bolts under steam pressure, etc. For such service it should be definitely ascertained that conditions are right from the start, without waiting until an accident occurs to show the need of precautions.

It is common practice in many plants to anneal chains periodically (about once in six months), in the belief that this will compensate for any adverse effects resulting from service conditions. If carried out with great care so that the proper temperatures are assured, this treatment may be of value, — otherwise it is liable to make conditions worse rather than improve them.

When a steel rod or other member which has been welded breaks at a point adjacent to the weld, it is generally assumed that this shows particular skill on the part of the blacksmith in making a strong weld. In reality it may mean that there is a point near the weld, where the conditions of temperature were just right to bring about the coarse-grained or crystalline structure; unless this is removed by subsequent annealing, the part is materially weakened.

In repairing a chain by inserting a new link, it is almost inevitable that some of the adjacent links will be heated to the critical point and be weakened by crystallization (having been previously critically stressed). As already mentioned, this condition may not seriously affect the tensile strength of the metal, but the conditions in a chain are such that the material in the links is not subjected to direct tensile stresses alone; when the chain is loaded so that elongation occurs, bending stresses are set up in the links, and these stresses will cause coarse-grained steel to fail under a load far below that which would be indicated by a tensile test. Proper annealing is the only remedy.

There is a similar hazard in connection with hooks used for hoisting, etc., and similar precautions should be taken as regards annealing. (See also "Chains" and "Hooks.")

Fatigue

Another element, which has to do with the failure of steel under loads of various kinds, is that of "fatigue." This is often considered as an effect of "crystallization," but it is undoubtedly something entirely distinct from the latter.

A steel member which is subjected to alternate stresses, such as may be caused by intermittent bending, torsion, vibration or shocks, is likely to fail in the course of time, even though the material is of good quality and the stresses are well within its elastic limit.

Such failure, however, seems to occur invariably in the form of a progressive fracture. A small crack starts at the point where the unit stresses are greatest, or where the piece is weakest on account of some imperfection, such as a blow-hole or a particle of slag in the metal, a dent in the surface, or even a tool-mark on the surface. (See Figs. 3 and 4, P. 153.) This crack grows under successive stresses until complete fracture finally results.

As indicating the action of steel under such conditions, some endurance tests made at the Watertown Arsenal are of interest. These tests covered a period of several years and included many samples, of which the following results are characteristic (see "Notes on the Endurance of Steels Under Repeated Alternate Stresses," James E. Howard, Proc. Am. Soc. for Testing Materials, 1907).

essential that all parts subjected to variable or alternating loads which may cause fatigue cracks should be designed with a higher factor of safety than those where the load is constant. A good practice is to double the factor of safety under such conditions; that is, — where a factor of four or five might be satisfactory for a dead load, the factor should be eight to ten for a live load.

Fortunately the stresses in an object under load are generally greatest at the surface, and incipient cracks can often be detected by careful inspection before the condition becomes dangerous. Annealing cannot remove a crack after it is once started, so entire dependence for avoiding accidents from this cause must be placed on inspection. A thorough examination of hooks, chains, or other parts upon which human safety depends should be made at regular intervals. Since a fatigue crack is usually small and difficult to detect under the most favorable conditions, the surface of the part under examination should first be thoroughly cleaned, and preferably treated with some substance, such as iodine, which will render the crack more readily visible.

When an incipient crack is found the part should, of course, be replaced immediately, as complete failure may result at any time.

Steel, 0.82% Carbon; Elastic Lim., 64,000 lbs.; Tensile Str., 142,800 lbs.		*Steel, 0.55% Carbon; El. Lim., 59,000 lbs.; Tens. Str., 111,200 lbs.*		*Steel, 0.17% Carbon; El. Lim., 51,000 lbs.; Tens. Str., 68,000 lbs.*	
Alternations which caused failure	*Fibre Stress sq. in.*	*Alternations which caused failure*	*Fibre Stress sq. in.*	*Alternations which caused failure*	*Fibre Stress sq. in.*
202,000,000 *	40,000	76,326,240	30,000	23,600,000 *	30,000
605,640	45,000	900,720	35,000	5,757,920	35,000
213,150	50,000	455,000	40,000	293,510	40,000
93,780	55,000	166,240	45,000	70,400	45,000
37,250	60,000	93,160	50,000	17,790	50,000
		12,490	60,000	6,470	60,000

* Not ruptured.

From this it will be noted that, with a proper factor of safety, many millions of alternations in load are necessary to cause failure, if the steel is in good condition at the start.

A live load may cause excessive fibre stresses on steel members. It is also impossible to make certain that the steel is absolutely perfect, i.e., that there is no internal flaw, such as a slag particle or blow-hole. It is accordingly

CHAPTER 17

MACHINE DESIGN, AND GUARDS FOR MACHINE HAZARDS

MACHINE DESIGN

THE designer of machinery is in the best position to apply proper safeguards. By giving attention to this matter at the time the original drawings are made, satisfactory safety conditions can usually be secured without difficulty, where it may be impossible to provide them later. In ordering new machinery, specifications such as are given in Chapter 4 should be used, in order to make sure that proper consideration will be given to safety features by the machinery builder.

Care should be taken in arranging clearances of machine parts to avoid shearing and crushing actions in which hands or other members might be caught and injured. Where such danger-points necessarily occur, they should be effectively guarded.

CONSTRUCTION AND ARRANGEMENT OF GUARDS

Convenience is one of the first requisites for a satisfactory guard. After it is placed in service the co-operation of the machine operator is necessary, in order to preserve the guard and secure its efficient use. Guards should accordingly be arranged so as to offer the least possible interference with the work of the machine attendant.

It is often necessary to reach the machinery inside a guard for inspection, adjustments, repairs, etc. Such work is usually done hurriedly in order to place the machine in operation again with the least possible delay. Unless the guard can be quickly removed and replaced, it is difficult to keep it in service. Wherever practicable, guards should be hinged or otherwise permanently attached, however, in order to prevent their complete removal. (See Page 157.) Unless this is done, accidents may occur on account of guards having been removed by workmen and not replaced again.

Single or Sectional Arrangement. Where there are several danger-points on a machine, the application of a separate guard for each danger-point or the use of sectional guards is preferable to a large general enclosure for all the danger-points. Single or sectional guards enable a workman who is repairing or adjusting the machine to expose only one point at a time. Where there is a large general enclosure the workman may get inside this enclosure or remove it entirely, and thus be exposed to several danger-points. Even though the machine is shut down, ordinarily, while such work is being done, it must be remembered that the adjustment of gears and other parts frequently requires the operation of the machine while the workman is observing it closely, so that, if several points are exposed, he may be caught in one while watching another.

Stability is a further requisite for machine guards. Such guards should be strong enough to withstand the handling to which they will be subjected, without injury, and without danger of their giving way and permitting an accident to occur in case persons should fall or be thrown against them.

Material for Guards. Iron and steel are preferable to wood, for the construction of guards. The greater first cost of metal guards is more than offset by the fact that, if properly made, they are practically indestructible under ordinary service conditions.

Woven wire fabric or perforated or expanded metal may be used where it is desirable to see through a guard and observe the working of the machinery inside of the guard. Wire fabric should be made of not less than No. 12 gage wire, and not greater than 1″ square mesh, or 1½″ diamond mesh.

Steel plate, where used for guards, should be not less than No. 16 gage, — preferably No. 14

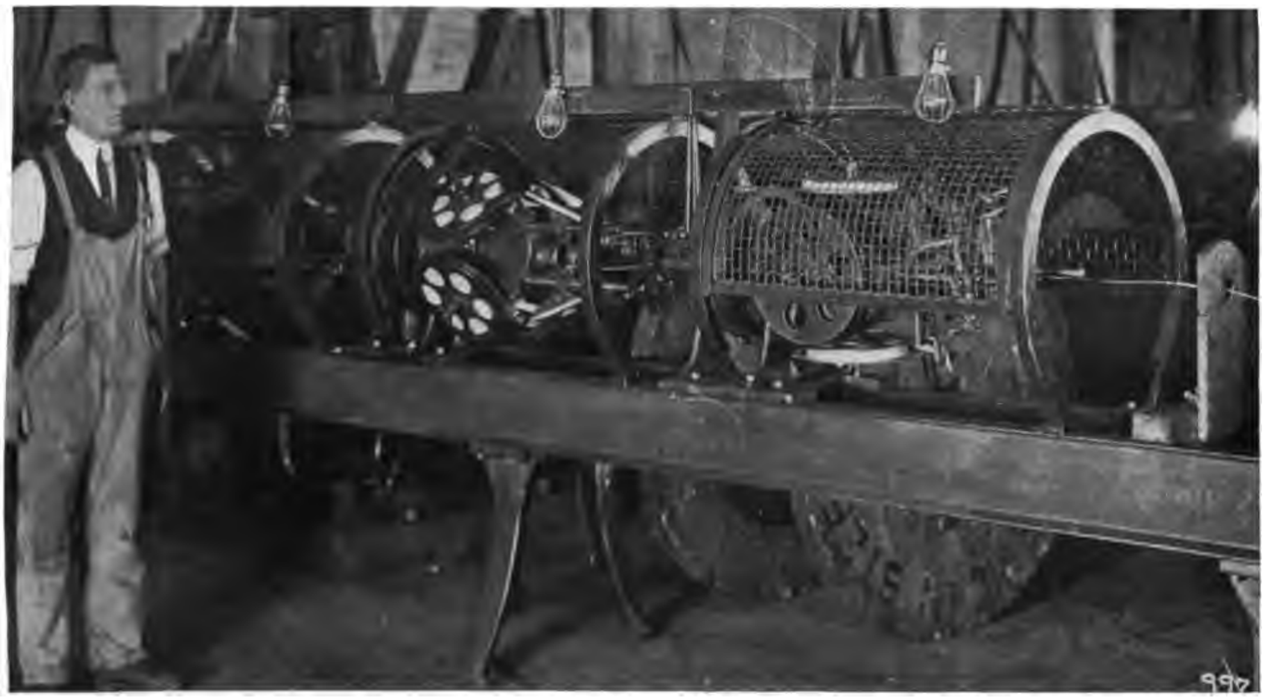


Fig. 1. Guards which rotate around Machine.*

The machine shown in Fig. 1 is provided with guards made up in sections, any one of which can be pushed back to give free access to the parts within. The sections are equipped with rollers which run in circular guides.

The guard in Fig. 2 is hinged to the post, so that it swings open like a door. The outer end runs on rollers. With this construction, the guard is in the way, if it is left open, which insures its being kept in position.

The guards shown in Figs. 1 and 3 expose only a part of the machine at a time.

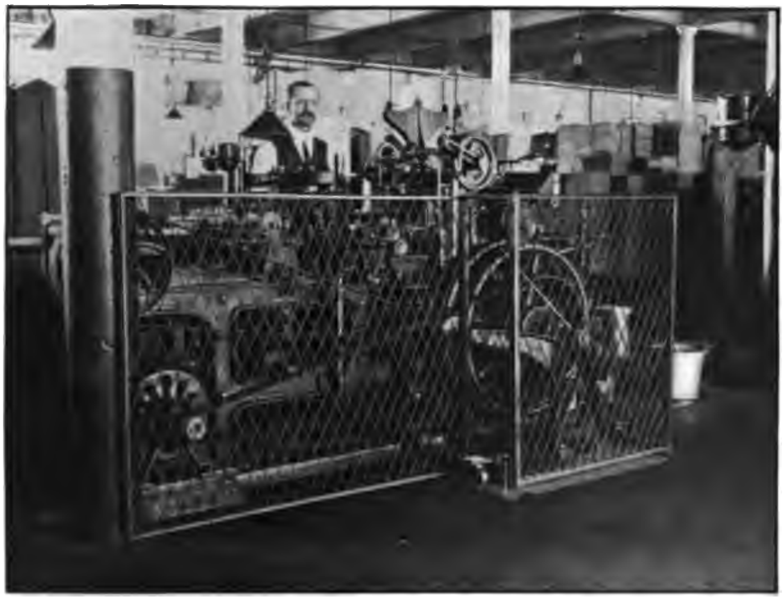


Fig. 2. Hinged Guard which swings horizontally. (Ginn and Company.)

Fig. 3. Guards which slide horizontally.*

*** Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.**

Fig. 1. Counterweight suspended underneath Floor.*

Fig. 1 shows an excellent arrangement for protecting counterweights, where conditions will permit of its use.

Fig. 2 shows an alternative arrangement, for use where the counterweight must be located above the floor.

Note also cover for roller train gears in the background of Fig. 2. This cover has handles by means of which it can be raised to reach the gears.

Convenient types of "transparent" guards are shown in Figs. 3 and 4.

Fig. 2. Counterweight protected by Steel Tube.*

Fig. 3. Sectional Counterweighted Guards which slide vertically.*

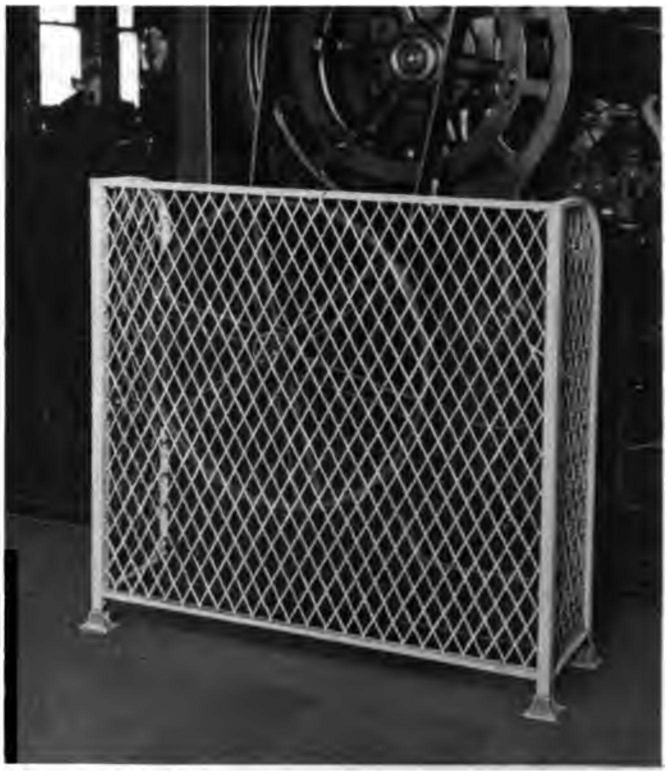


Fig. 4. Type of Guard which may be used unattached, pivoted at one Foot or resting in Sockets.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

gage or heavier for large guards and those which may be subjected to rough usage.

Cast iron furnishes an excellent material for the construction of gear guards and other forms of protection which are not so large as to make the relatively greater weight of cast iron objectionable. Where a number of duplicate guards can be made, thus distributing the cost of patterns over several castings, the expense of cast-iron guards compares favorably with that of other materials. Where only one or two guards of a single kind are required, it is usually less expensive to make them of sheet steel or metal grill-work.

Wooden guards are objectionable from the fire standpoint since they are likely to become saturated with oil. Much woodwork of this sort will add materially to the fire hazard, and may increase the fire insurance rate. Wood offers more resistance to acid fumes, however, than metal, and may be advisable in some special circumstances.

Wood, where used for guards, should be not less than $\frac{7}{8}''$ in thickness.

Finish, etc. Regardless of the material used, all guards should be of rigid construction, and securely fastened in place. Guards should be finished in such a manner as will leave no sharp corners or rough edges on which persons may be injured.

MACHINE HAZARDS

Although modern industry has developed an infinite variety of machines, adapted to a wide range of uses, all machinery can be divided into a few simple mechanical motions. Each of these motions has its own particular hazard and requires a special safeguard. When these mechanical actions are clearly recognized, it is possible for an experienced inspector to pick out the danger-points of any machine, whether he has had long familiarity with it or not. There are crushing, shearing and rotating actions, the common forms of which are as follows: —

1. Driving belts, ropes, chains, etc.
2. Gearing.
3. Shafting, couplings, etc.
4. Rolls.
5. Knives or cutters.
6. Reciprocating parts, traversing carriages, etc.
7. Miscellaneous revolving parts (cranks, governors, rotating heads, etc.)
8. Counterweights.

Driving Belts, etc. The principal hazard from driving belts, ropes and chains, lies in the danger of persons being caught between the driving and the rotating members, at the point where they run in contact. The danger is obviously greater for a heavy driving belt than for a light one, and the inspector is confronted with the question as to when, if at all, a belt shall be considered light enough to require no protection. This is a difficult matter to decide, and no uniform rule can be established.

It would seem reasonable to make the dividing line for flat belts, at about two inches in width where little power is transmitted. Belts which are tight, however, and run at high speeds, may afford a considerable element of hazard even though they are less than two inches wide. The safe plan is to enclose all belts, regardless of width.

Where round belts or ropes are used, the hazard is relatively greater, for small sizes, than where flat belts are used. A finger might be crushed or broken by being forced into the groove of a sheave, while it would be carried around a flat pulley without serious results.

Chains and sprockets are the most dangerous of all, on account of the facility with which they catch clothing or hands, and the lacerating effect of the sprocket-teeth.

Sometimes a belt shifter is placed close to the pulley and arranged so as to practically eliminate danger of any one being caught between the belt and the pulley. The hazard, however, is not confined to this source alone; bad lacerations may occur from contact with the edge of a rapidly moving belt. Guards are accordingly desirable in order to prevent injuries from the edge of the belt, aside from their value in protecting the contact point between belt and pulley.

For protecting driving belts within 7′ of floor or platform level, the following standards are recommended. These standards should also be construed to cover ropes, chains, sprockets, etc. (For Standards covering the protection of belts more than 7′ from the floor, see Chapter 15.)

Standards. Guards shall be of substantial construction, securely fastened in place, and of such size and arrangement that persons walking through passageways or open spaces cannot strike the edge of a running belt, and an arm (assumed to be 2′ in length*) cannot project through, over or around side of guard and be caught between the belt and pulley, or injured by spokes of pulley. (See Fig. 1, P. 161.)

Where railings are used for such guards, they shall be covered with wire fabric, sheet metal, or other material, at all points where an arm projected through the railing might be caught between belt and pulley or injured by spokes of pulley.

Where a guard or enclosure is within 4″ of contact point of belt and pulley, and there are openings through the guard more than ⅜″ in width through which fingers might project and be caught between belt and pulley, such openings shall be completely covered or protected by suitable material, such as wire netting of not more than ⅜″ square mesh not smaller than No. 20 gage wire. (See Fig. 1, P. 161.)

Minimum height (from floor line) recommended for belt guards, — 3′ 6″.

Clearance between running belt and exposed edge of guard shall be not less than 6″, for any guard less than 5′ in height.

Belt Shifters. All belt-driven machines should have tight and loose pulleys, equipped with mechanical shifters for manipulating the belts. (See Page 163.) Shifters should also be provided for cone pulleys. (See Page 164.)

It is important to have belt shifters arranged so they will lock or latch automatically, on the loose pulley. This prevents danger of the belt creeping from loose to tight pulley or being shifted accidentally, and catching the operator unawares when he has stopped the machine for adjustment or repairs. (See Fig. 4, P. 167.)

It is well to have the shifter latch automatically on the tight pulley also. Unless this is done the belt may, under certain conditions, tend to creep on to the loose pulley. To prevent this, the machine operator may fasten the belt on the tight pulley in such a manner that the machine can be quickly stopped in case of accident.

Where a belt shifter consists of a sliding lever, a satisfactory latching device can often be secured by merely notching the support on which the rod or lever rests. (See Fig. 2, P. 256.) Other forms of locking shifters which would prevent danger of belt creeping, at the same time permitting it to be shifted readily, are shown on Page 163.

Belt Fastenings. The best form of belt fastening is the "endless" or glued joint. Belt lacing necessarily distributes the strain unequally across the width of the belt, and there is a tendency to tear out at the points of contact, so that the full strength of the belt is not developed.

The glued joint is more permanent and increases the life of the belt; at the same time it affords the highest degree of safety. Next to this in desirability, comes the use of rawhide belt lacing.

When a new belt is being installed and it is necessary to place the machine in operation immediately, metal lacing may be used temporarily and the belt made endless after the "stretch" has been taken out of it. The use of metal lacing at the start saves time in shortening the belt, as is usually necessary, and if such belts are guarded along the lines already advocated, there is not much danger from the lacing.

Metal fasteners should never be used in belts which are manipulated by hand, however, or with which persons are likely to come in contact. In general the use of metal lacing is advised against, as it is liable to become worn or distorted in a manner which will leave sharp projections and cause accidents.

* This assumption is desirable, since a person stumbling or slipping may fall with an arm over or through a guard, and the contact-point of belt and pulley should be out of reach, under such conditions. 2′ is accordingly recommended for new equipment. For application to existing equipment the standard may be modified to read "a fore-arm (assumed to be 15″ in length)" etc.

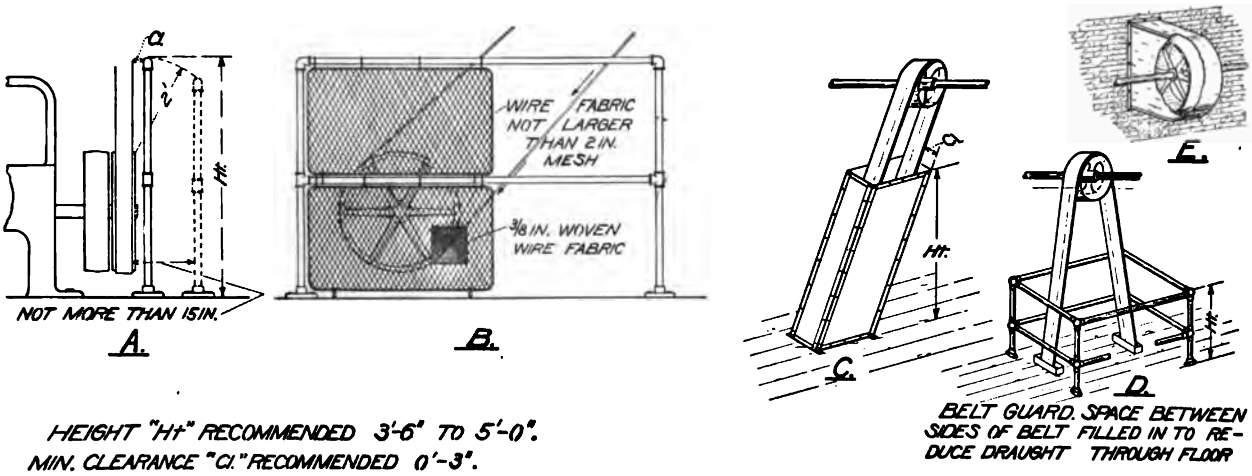


Fig. 1. Types of Belt Guards.

Fig. 2. Guards for Individual and Main Belts. (United Shoe Machinery Co.)

Fig. 3. Machine Guards of Sheet Metal and Woven Wire Fabric.*

Fig. 4. Barbed Wire Fence Machines, before and after guarding.* Fig. 5.

* **Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.**

Fig. 1. Scene of Accident on Machine Pulley.

A partial guard may give a false sense of security and cause, rather than prevent, accidents. Fig. 1 shows how a man was injured as the result of resting his foot on the guard across top of pulley.

A man had his hand caught and torn off while attempting to replace belt on pulley shown in Fig. 2. This was the only way provided to start the machine.

Fig. 2. Accident on Overhead Pulley.

Fig. 3 shows a belt guard of steel plate. A small detachable section has been provided for oiling the pulley, and the whole face of the guard can be removed for making adjustments, replacing the belt on the pulley, etc. This guard is "shoulder high" (about 5′).

A neat type of belt guard is shown in Fig. 4. This guard is made up in hinged sections which can be quickly opened when necessary. The side swings outward like a door. There is sufficient clearance underneath the guard to permit of floor being swept.

Fig. 3. Belt Guard. (American Steel and Wire Company, subsidiary of United States Steel Corporation.)

Fig. 4. Drill Press Belt Guard. (Stevens Institute of Technology.)

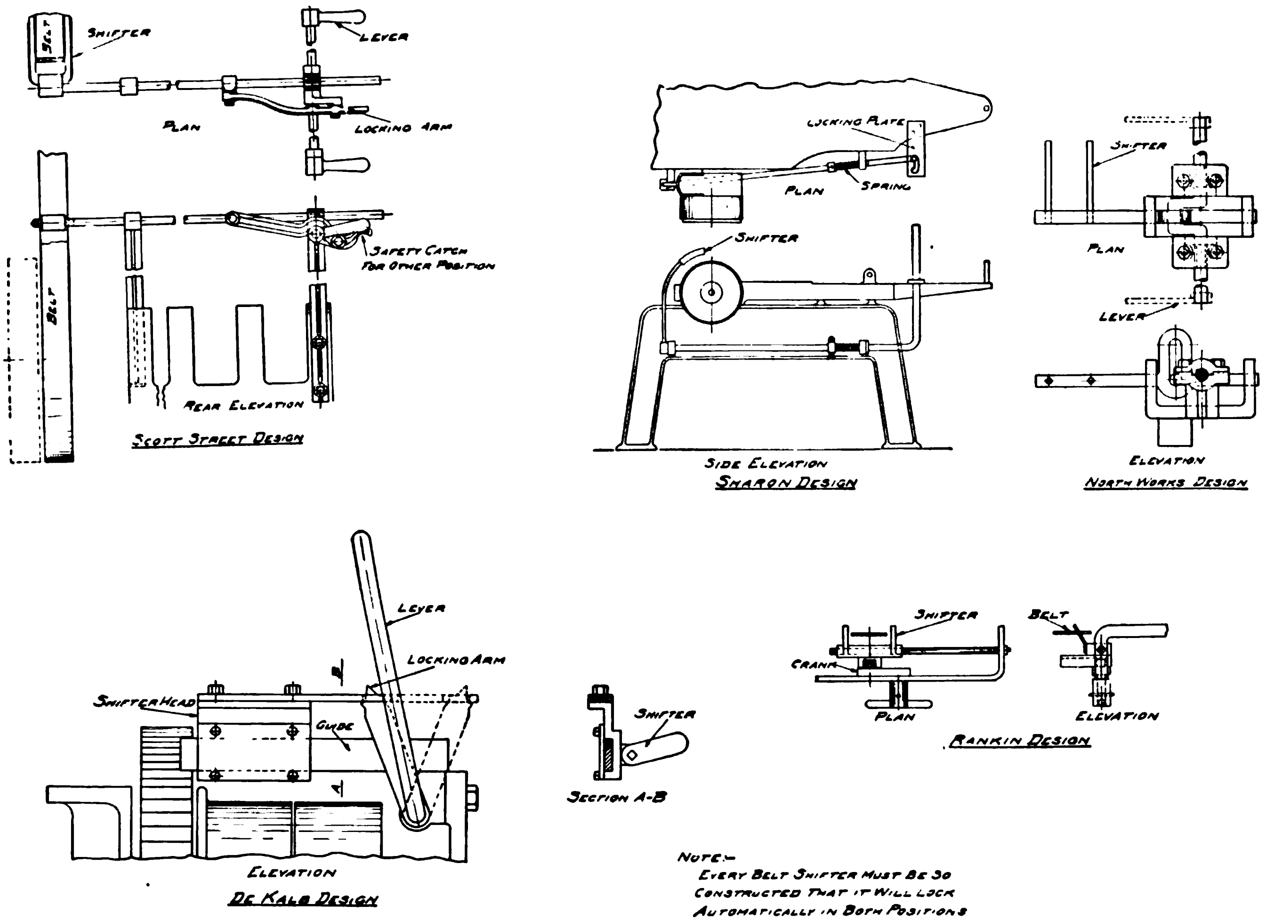


Fig. 1. Types of Safety Belt Shifters.*

Fig. 2. Photograph of Safety Belt Shifter as applied to a Machine.*

Every belt-driven machine should have a shifter, arranged so that it will lock automatically in both "on" and "off" position. Various types of locking-shifters are shown in Fig. 1. This prevents danger of the belt creeping from loose to tight pulley and starting the machine unexpectedly; the shifter also holds the belt on the tight pulley, doing away with any likelihood of the operator fastening it "on," in such a manner that the machine cannot be quickly stopped in case of emergency.

Fig. 2 illustrates one application of the "Scott Street Design." By manipulating lever "A," shaft "B" may be rotated either way by means of the gearing (indicated by the arrow). Connecting rod "C" is pivoted at one end to shifter "D" and attached at the other to a short crank fixed in position on shaft "B." This crank throws the connecting rod back and forth as shaft "B" is rotated, thus shifting the belt. Connecting rod "C" drops past the centre of the crank in both positions and affords a positive lock.

A cord may be attached to lever "A," which can be pulled to stop the machine from a distance.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Locking Shifter for Counter-Shaft. (Pat.)

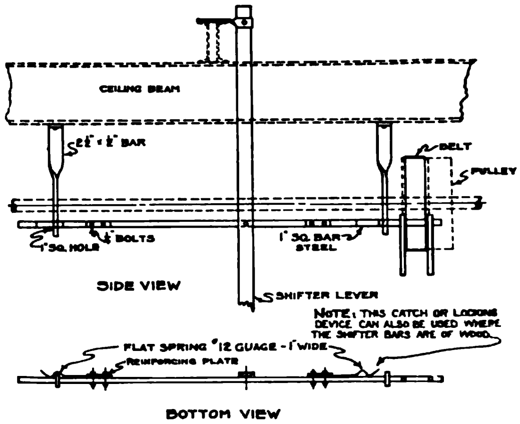


Fig. 2. Locking Shifter for Counter-Shaft. (Amer. Steel and Wire Co.)

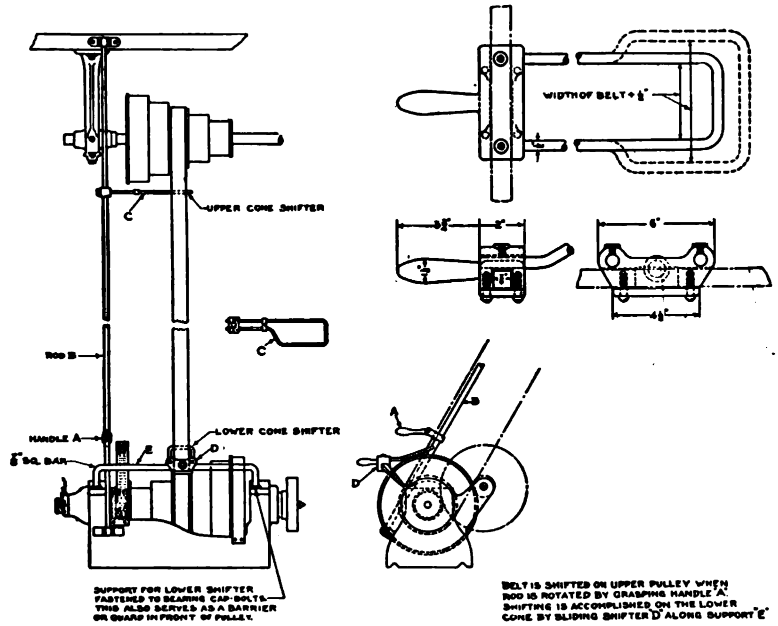


Fig. 3. Cone Pulley Belt Shifter. (Device for upper cone patented.)

Fig. 4. Cone Pulley Belt Shifter.*

Figs. 1 and 2 show methods of applying locking devices to the overhead belt shifters commonly used on countershafts.

Two types of cone belt shifters are shown in Figs. 3 and 4. An independent device is provided for shifting the belt on the upper and lower pulleys, thus making it unnecessary for the operator to touch the belt with his hands. A slight saving in time is also effected in many cases by the use of such a device.

(See also pages 207 and 208, which show lathes equipped with the device illustrated in Fig. 3.)

* Courtesy of Carnegie Steel Company, subsidiary of United States Steel Corporation.

Fig. 1. Belt Guard.

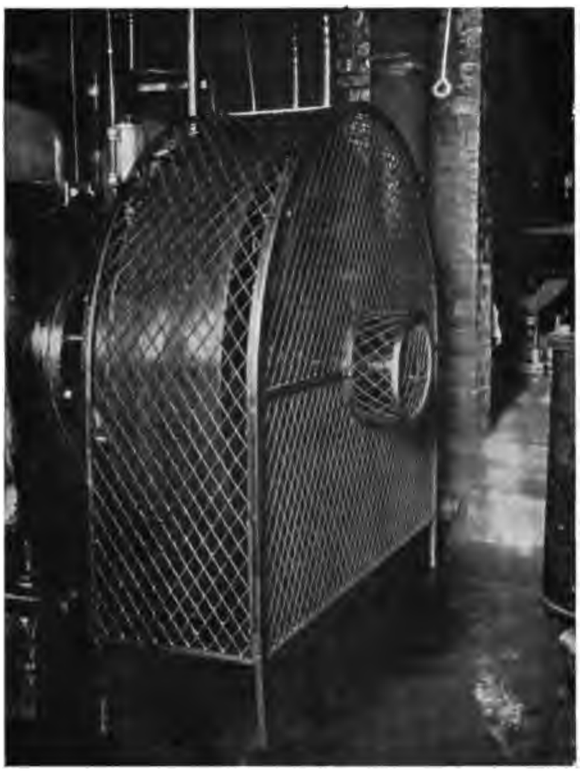


Fig. 2. Guard for Small Fly-Wheel.

Fig. 3. Protected individual Motor Drive.

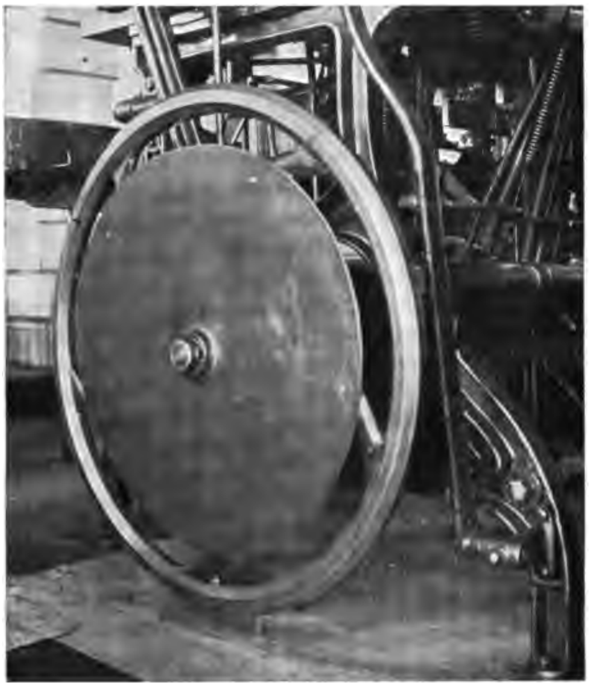


Fig. 4. Fly-Wheel Guard.

Attention is directed to the neat appearance of these guards, and their effective arrangement from the standpoint of convenience and utility.

Gearing. Gearing is found in nearly all machinery, and constitutes a serious accident hazard in every industry. This hazard is generally recognized in accident legislation, although in many States the wording of the laws is so indefinite as to make their enforcement difficult.

The trouble lies in trying to draw fine distinctions between gears which should be classed as "dangerous" and those which should not. Repeated experience has shown that the *only* safe gear is one which is so enclosed or guarded as to make accidental contact with it impossible.

The danger is, of course, greater in some cases than in others; where gears run "out" and where the mesh-point is inaccessible, the hazard may be so slight that it can be disregarded, *unless* a shear is formed between the teeth of the gear and some adjacent member. Accidents may thus occur, even on gears running "out," and loose clothing, hair of women operatives, etc., are liable to be caught.

It is expecting too much to assume that persons working about machinery should always be on the alert, and in this way avoid being caught in exposed gearing. The operation of the machine must necessarily require complete attention all, or much of the time, and the operator whose mind is continually distracted by thinking about the danger of exposed gearing, will be of little value to his employer.

There is always the possibility of persons slipping or tripping and throwing out a hand to re-gain the lost balance; of their reaching for a fallen object; of their climbing overhead for some purpose such as painting, whitewashing, adjustment of an electric light or piping. In these and many other ways which are difficult to anticipate before-hand, persons have been caught in gears which are out of the way, or located where the hazard would not seem to be a striking one. (See Page 167.) It is accordingly desirable to guard exposed gears, irrespective of their location.

For this purpose the following standards are recommended:—

Standards. Gears, unless so located that accidental contact with them is impossible, shall be wholly enclosed, or have a band guard around face of gear with side flanges extending inward beyond root of teeth.

Guards must be of substantial construction, securely fastened in place, and of such design and arrangement that an arm or hand cannot project through, over, around, or underneath guard and be caught in mesh-point of gears, or between gear-teeth and adjacent framework or other fixed part, or be projected through gear, where the latter has openings between the arms or through the web.

Where a guard or enclosure is within 4″ of the gears, and there are openings through the guard more than ⅜″ in width through which fingers might project and be injured by the gears, such openings shall be completely covered or protected by suitable material such as wire netting of not more than ⅜″ square mesh, not smaller than No. 20 gage wire.

Gear accidents. The following list gives an analysis of the causes of 74 gear accidents reported to one insurance company during the course of a year. Many typical cases are included in this list, which illustrates nearly all the common causes of gear accidents:—

Cleaning running machines (two of these accidents were caused by putting hand under guard)	20
Removing waste from running machines (two of these were with guard off)	4
Oiling machines (in one case machine started, unexpectedly, in the other it was already in motion)	2
Repairing machines	4
Placing or removing work, etc.	7
Operating machine (sleeve caught in one case, drawing in hand)	4
Reaching for something (to shut off power in one case)	6
Trying to stop machine (by catching hand-wheel in three cases, catching gear in one)	4
Putting belt on pulley	1
Slipped and fell into gears (in one case hand slipped while tightening nut)	5
Machine started with hand on gears	4
Lathe gearing (one while cleaning, three while changing gears)	7
Fooling around machine	1
Attention distracted from work	1
Setting dog on gear	1
Hand-operated gearing	1
Miscellaneous	2
Total	74

Fig. 1. Gear Accident at Loom.

Fig. 2. Gear Accident at Feed Rolls.

These pictures show the scenes of three gear accidents occurring where the hazard would seem to be slight. A brush used to clean the gears, as shown in Fig. 1, was caught, drawing hand of operator into gears. Similar accidents have occurred from the use of waste, rags, etc.

All gears in Fig. 2 were guarded except feed-roll gears; these, being back of the rolls, were not considered dangerous. In reaching for a piece of scrap, however, a sleeve was caught, drawing arm between gears and causing a bad accident.

Fig. 3. Gear Accident.

Fig. 4. Starting Accident.

The gears in Fig. 3 are thoroughly enclosed on the outside. They are open, however, on the inside, and the operator, reaching up to remove some scrap as illustrated, had his fingers crushed.

Fig. 4 shows how a man was fatally injured by the unexpected starting of a loom. An employee in passing struck the starting lever and the man's head was crushed between the frame and reciprocating beam. A locking shifter would have prevented this accident.

Cleaning and Oiling, etc. It will be noted that twenty-seven of these accidents, or more than one-third of the total number, occurred through cleaning or oiling machinery, removing waste, etc., with the machine running.

It is well to have a rule requiring machinery to be shut down while such work is being done. It is difficult to enforce such a rule, however, at all times, particularly where the piece-work system is in force, and every stoppage of the machine means a direct loss to the operator.

Under such conditions the only effective means of preventing accidents is to guard all gearing and other danger points, so that minor work of this character can be safely accomplished while the machine is in operation. (Interlocking guards, which cannot be opened while the machine is running, are practicable in many cases. See Pages 289 and 314.)

A considerable percentage of the accidents reported above, resulted from ordinary work around the machines, handling material, reaching to shut off power, etc., while carrying out customary operations, for which the operators were in no way blameworthy.

The cases where the machines started while a hand was on the gears, indicate the necessity of having locking belt shifters or other positive power-disconnecting devices, as well as gear guards.

Other accidents show the danger of loose clothing, the hazard of trying to stop a machine quickly where a regular brake has not been provided, etc. In one case, "fooling" was responsible for the accident, but only a small portion of the whole number could be attributed to culpable carelessness on the part of the operator.

Unexpected Starting. In some cases, accidents were caused by one person starting a machine while another was oiling or working in such a position that the unexpected movement of the machinery resulted in his being caught. This shows the desirability of making it the duty of some one person to start the machine, particularly where there is a regular operator and an assistant, so there will not be any divided responsibility. Machines may also be arranged so that the concerted action of two persons is necessary to start them.

Hand-Operated Gears. It is commonly considered that there is no accident hazard from gearing on machines driven by hand; one such case, however, is included in this list and there are many others on record. The human body offers little resistance to mechanical injury, and there is often enough momentum in moving parts to do the damage before they come to a standstill. Where hand cranes or hoists are concerned, there is the added danger of the load reversing the gears, in which case they are virtually power driven.

Incomplete Guards. In several of the accidents included in this list, hands were caught underneath a guard which was ineffective because it did not completely enclose the gearing. Nearly all of the accidents, however, occurred on unguarded gears, and there is no doubt but that a large majority of them could have been prevented if the gears had been protected. Owing to the crushing action of gears, to be caught in them generally means a permanent mutilation or disfigurement, if not the entire loss of the member.

Application of Gear Guards. Where this matter is given attention at the time a machine is designed, guards can readily be adapted to all gearing. For equipment already in place which has exposed gearing, the problem is somewhat more difficult. Many machinery builders, particularly the manufacturers of machine tools, have made up patterns for gear guards, castings of which may be obtained for even the older designs of machines.

It is possible, however, for any trained mechanic to work out satisfactory guards, and there is no fundamental reason why all gearing in a given plant cannot be protected. The author has in mind a plant covering more than twenty acres and containing thousands of machines with gears on them, careful inspection of which failed to show a single exposed gear.

Shafting, Couplings, etc. Wherever revolving shafting used in a power-driven machine is

Fig. 1. Scene of Shafting Accident.

Fig. 2. Skirt Guards for Shafting. (Courtesy General Electric Co.)

In stooping to pick up a fallen object, a girl had her hair caught on the shaft underneath bench shown in Fig. 1. A considerable part of her hair was torn from the scalp. She was disabled for more than three months as a result of the injury and shock. This shaft was protected by a common form of narrow skirt guard, as shown in the photograph.

Fig. 2 illustrates a superior form of skirt guard which thoroughly protects the shaft. The projecting end of the shaft is also boxed in.

Fig. 3. Extension Oil Pipes on Fence Machine.*

Fig. 4. Extension Oil Pipes, on Wire Drawing Frame.*

While it is desirable to oil bearings only while the machinery is shut down, this is not always practicable. Figs. 3 and 4 illustrate the use of extension oil pipes, by means of which bearings can be oiled safely while the machinery is running.

Note permanent platform at top of fence machine, illustrated in Fig. 3, for use of oilers, repairmen, etc.; also chain hoist on truss. The guards over the machine can be removed in sections.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

exposed to contact, it should be guarded, in order to prevent its catching and winding up the clothing of operators. (See Fig. 4, P. 173.) The hazard exists even though the shaft is perfectly smooth; any projections or irregularities, however, increase the danger. If fixed guards are impracticable, a loose sleeve may be placed around the shaft so that it ordinarily revolves with the shaft, but will stop if touched from the outside. (See Fig. 4, P. 328.)

Unused shaft-ends projecting from pulleys or other machine parts 2″ or more should be guarded (see Fig. 2, P. 142, and Fig. 4, P. 65); key-ways should be filled so as to present a smooth surface (see Fig. 1, P. 289); set screws should be countersunk or guarded, — or hollow screws which do not project beyond the surface may be used; couplings, unless thoroughly guarded (see Fig. 4, P. 173), should be of safety type, without projecting bolt heads or screws; all other parts on revolving shafting such as universal joints, clutches, etc., having irregular members which might catch in clothing, should be thoroughly enclosed or guarded. (See Figs. 3 and 4, P. 143.)

For standards recommended for the protection of exposed shafting, see Chapter 15.

Rolls. Many types of machines are equipped with rolls of various kinds, which feed the stock, or work upon, or finish it. Such machines are prominent in the steel, paper, leather, textile, and rubber industries, as well as in laundries, wood-working shops and many other industrial plants.

Where the material handled is not too thick, and where it is of even and regular character. it is usually possible to place a bar or roller at a height (say $\frac{3}{8}''$) which will just clear the stock; this permits the material to pass through, but offers a positive obstruction to fingers or other members which might be caught by unprotected rolls. Such guards may often be made a part of the guides or rests which are necessary to direct the stock which is being worked upon. (See Figs. 1, 2 and 4, P. 328.) Where large pieces of leather or other material which does not "lie flat" is being handled, a funnel-shaped piece may be used, to guide the stock under the guard.

In some cases the material is so bulky or so irregular in character that a guard of this type could not be installed. In this category rubber mixing rolls, stone crushers, etc., might be cited as examples. Sometimes it is possible to provide hoppers for feeding such equipment, which prevent dangerous proximity to the rolls. In most cases, however, dependence must be placed upon stopping the machine as quickly as possible when an accident occurs. This means, that there should be provision for instantly disconnecting the power, which may be taken care of, in many cases, by a trip-cord or bar in front of the operator. (See Fig. 4, P. 137, Fig. 1, P. 263, and Fig. 1, P. 315). Wherever practicable this trip-cord or bar should be so located that the operator will strike it automatically or instinctively, if caught in the machinery.

In addition to disconnecting the power, a brake is necessary in many cases, in order to overcome the momentum of moving parts, and stop the machine promptly. To this end, electric drives with dynamic braking furnish the ideal arrangement. The use of this principle for providing quick emergency stops, although limited at present, will undoubtedly have a wide application as time goes on, and its value becomes generally recognized. (See Fig. 5, 1 and 2, P. 179.)

Knives or Cutters. The safe-guarding of shears and cutting machines usually furnishes a difficult problem.

In general, all unused portions of the knives should be guarded, merely allowing sufficient room to admit material. (See Fig. 4, P. 301.) If the openings for this purpose are, say one-half inch or less, there is little danger of injury; where large openings are essential, an effort should be made to have the arrangement such that it will not be necessary to bring the hands close to the cutters.

In some cases, it is possible to place guards or railings so that the operator is kept at a safe

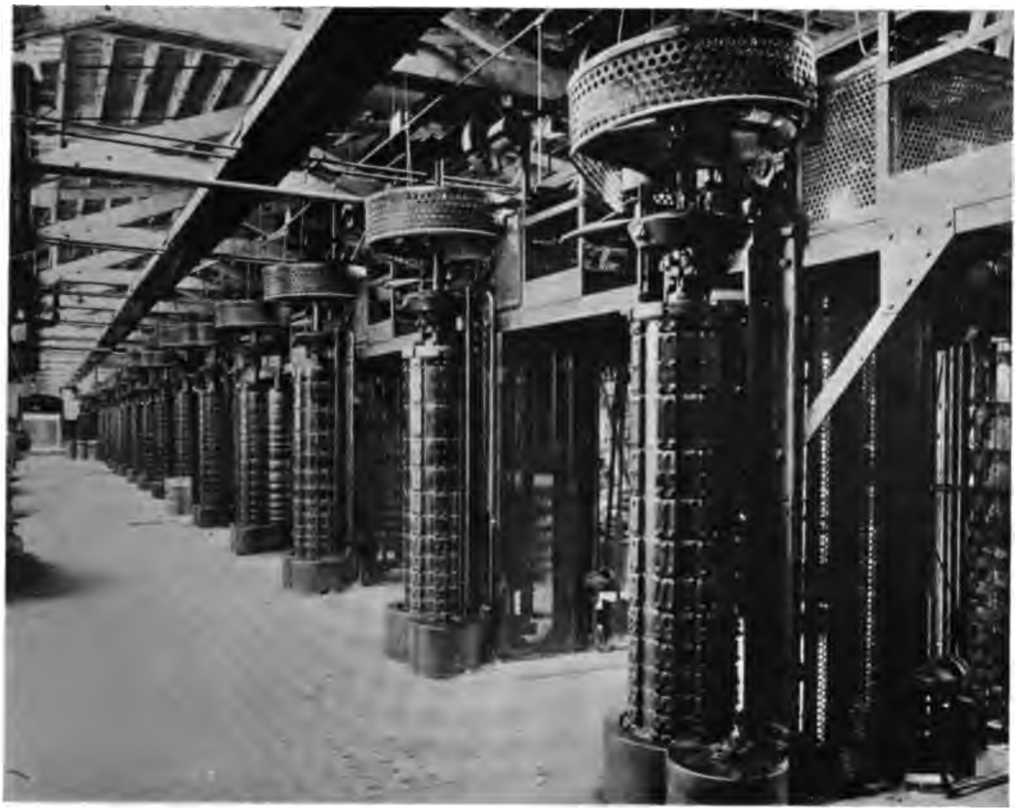


Fig. 1. Wire Fence Machines protected by Perforated Metal Guards.*

In Figure 1 is shown an excellent arrangement of safeguards, made from perforated metal with structural steel framing. The neat and effective manner in which this material has been utilized is apparent from the photograph.

The gears are protected by cast-iron guards so designed as to conform to shape of the gear. Permanent working platforms are provided at the top of the machines. The blue light and sign which mark the motor stop-button are just visible at the left-hand side of the photograph.

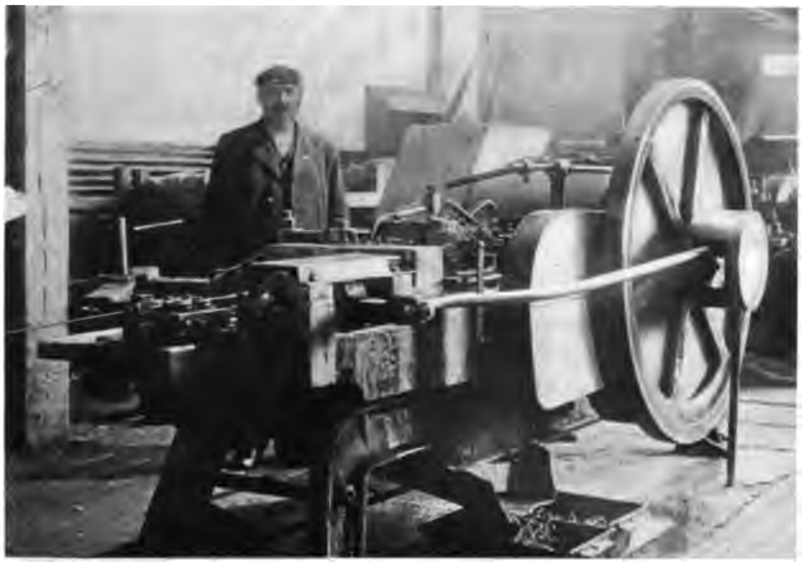


Fig. 2. Guards for Belt, Fly-wheel, Crank Adjusting-Block, Crosshead, and Gearing of Nail Machine.*

Fig. 3. Guard for Needle of Sewing Machine. (Pat.)

Fig. 3 shows a simple guard for the protection of sewing machine needles. During the past year, three fatalities have occurred in one state from infection resulting from needle punctures in fingers of sewing machine operatives.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

distance; in others, where small pieces of stock must be fed into the knives, holders or tools of wood or other material can often be employed so as to protect the fingers of the operator. (See Fig. 1, P. 328.)

Another expedient for keeping the operators' hands out of danger is to have two hand levers, separated somewhat, both of which must be pressed simultaneously to operate the machine. (See Fig. 2, P. 198.)

Reciprocating Parts, Traversing Carriages, etc. Many machines have reciprocating parts which move back and forth rhythmically and which are liable to catch and crush hands or other members. (For example, engine cross-heads. See Fig. 3, P. 99.) Sometimes two parts move simultaneously, as in the pantograph, but more commonly the crushing action is formed between a moving part and the framework of the machine.

This is a feature which should receive consideration, whenever machinery is being designed; where sufficient clearance cannot be allowed to eliminate the crushing effect, guards should be provided to protect the danger-point.

In some cases, where a shear-action is formed by a skeleton member moving past a solid part, a solid member moving past an open part, etc., the danger may be obviated by filling the openings so as to do away with the shear. (For example, planer-beds,—Fig. 1, P. 205.) Bevel plates may also be used, under certain conditions. (See Fig. 1, P. 191.)

Where reciprocating parts of machines, such as planers, shapers, mule spinning frames, etc., project beyond the frame of the machine, sufficient space should be left between such parts and other machines or adjacent fixed structures (such as building columns) to provide adequate room for attendants. Two feet clearance is recommended as a fair minimum standard, and the clearance should never be less than 18″.

Miscellaneous Revolving and Rotating Parts. Where cranks or cams are used, care should be taken to see that a crushing or shearing action is not formed with the adjacent framework or other parts.* (See Fig. 3, P. 173.)

Some machinery parts such as fly-ball governors, heads of wire straightening and cutting machines, etc., revolve at such speed that persons working near them may be struck and seriously injured, or thrown into a position where serious injury may be received from some other part of the machine. All such parts should be so enclosed or guarded as to prevent danger of accidental contact with them while in motion. (See Fig. 2, P. 105.)

Counterweights. Counterweights should be suspended in such locations as to offer the least possibility of injury in case they should fall. Where they are not naturally protected by the arrangement of the machine, an enclosing guard or guide should be provided, within which the counterweight rises and lowers. (See Page 158, also Fig. 2, P. 210.)

In some cases additional precautions may be necessary to prevent injuries from the objects which are counterweighted (doors, machine parts, etc.) in case the counterweight support should give way. For supporting heavy objects, cables should be used instead of chains. Two small counterweights may be used instead of one large counterweight; where this is done entire dependence is not placed on a single support.

Automatic or Mechanical Feed. There are many machines such as punches, woodworking machinery, etc., in which there is an inherent hazard at the point of operation. Conditions are necessarily such that space must be left for the stock to be worked upon, and if a hand should enter this space it would be injured.

An effective way to reduce this hazard is to provide some form of automatic or mechanical feed, by means of which the stock worked upon is fed into the point of operation mechanically, without any necessity for operators

* The author recently visited a plant where all the looms of a certain type were being changed over at considerable expense, after one of the workmen had his arm crushed between a crank and cross-piece; this crank was located underneath the machine where it would seem to be in a safe place, but in reaching through the frame for some object the man was injured.

Fig. 1. Belt Guards for Bench Drills.

Fig. 2. Sectional Guard.*

It is desirable to guard the belts of small bench machines, as shown in Fig. 1, particularly where they are operated by girls. These guards prevent danger of hair being caught by the belt, or fingers being caught between belt and pulley.

The guards shown in Fig. 2 are held in position by spring clips, making them readily detachable.

Fig. 3. Guarded Crank, etc.*

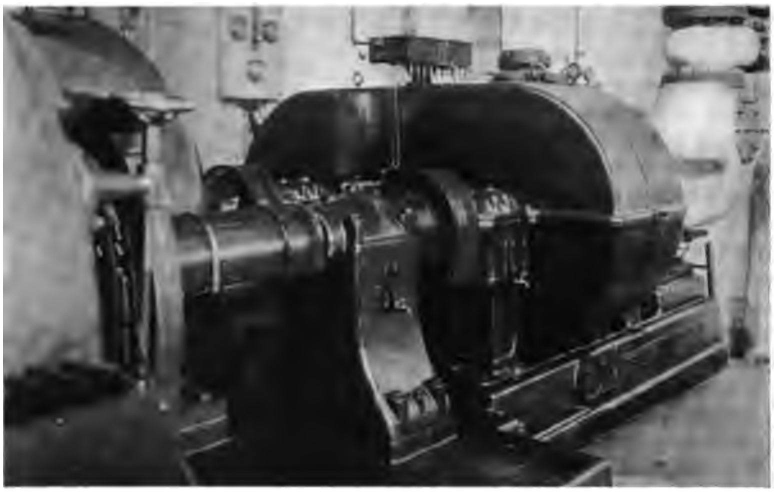


Fig. 4. Guarded Shafting, and Couplings of Turbine Drive.*

Fig. 3 shows a horizontal guard over crank disc of thread-rolling machine. Gear and belt guards are also provided, the latter being attached to the machine so as to leave the floor space underneath it clear.

Fig. 4 shows an excellent type of guard for low shafting and couplings.

* Courtesy of Remington Typewriter Works.

bringing their hands near the danger-point. (See Pages 196 and 217.)

Automatic or Mechanical Starting. In some cases automatic or mechanical devices are of considerable value from the safety standpoint in reducing the hazard of starting machinery. This is especially true of the stationary gas engine, and the familiar type of gasolene engine used in automobiles. The safest method for starting such engines is to provide an electric motor, compressed air or other similar device for turning the engine over until its normal operation begins. Where cranks are used, they should be of a safety type, which will either lock or release in case of back-fire. Without such a device, serious accidents may result from reversal of the engine.

For starting large steam engines which have stopped with the crank on "centre," a small starting engine may be geared internally to the fly-wheel. A lifting jack, operating in depressions provided for that purpose around the face of the wheel, may also be used.

Individual Control. All machines should be arranged so they can be shut down individually. This may be accomplished by the use of tight and loose pulleys, friction clutches, etc. Throwing the driving belt off and on to stop and start a machine, as is sometimes done, involves considerable hazard, and has resulted in many accidents. (See Fig. 2, P. 162.)

Treadle Locks or Treadle Guards may be of value, where machines are operated by foot-treadles, to prevent the machines being started unexpectedly by an accidental touch on the treadle. (See Fig. 3, P. 194, and Fig. 3, P. 316.)

Lubrication. Some safe method should be provided for properly lubricating all friction surfaces. Where oil-holes are not readily accessible, the difficulty may be overcome by permanently attaching one end of a pipe or tube to the oil-hole, and carrying the other to a point where it can be reached conveniently. (See Figs. 3 and 4, P. 169.)

Belt Perches should be provided, for use where it is necessary to throw a belt off the pulley while making repairs, etc. (See Fig. 7, P. 147.)

CHAPTER 18

CRANES

ELECTRIC TRAVELING CRANES

THERE are certain inherent dangers in connection with Electric Traveling Cranes, which class them with the extra-hazardous types of machinery.

They have the common mechanical risks of gearing, shafting, couplings, etc., to which is added exposure to electrical conductors which are necessarily bare. There is danger from moving bridge and trolley wheels, and, in addition, there is the possibility of falls from the crane, which offer an independent source of danger, and which may add the final stroke of fate to a man who has received an injury, otherwise trivial, from one of the first mentioned sources.

Climbing to and from the cranes subjects the operator to further risks, and where more than one crane is located on the same runway, collisions and other accidents are liable to result from the cranes coming in contact with one another.

Nor is the exposure confined to persons on the crane. Those underneath may be struck by loads which the crane is carrying. The load may fall from its supports, or some part of the hoisting mechanism may give way and let it drop. Gears or other parts on the crane may break or work loose and fall upon persons below.

All this means that special and thoroughgoing precautions must be taken, if the accident record of the crane is to be kept within reasonable bounds. The following pages contain an outline of such precautions; for the convenience of those using them they are arranged under the head of Specifications, Installation Requirements, and Operating Rules.

The Specifications and Operating Rules were embodied in a paper by the author, presented before the Engineers' Society of Western Pennsylvania, March 12, 1912.* In this connection indebtedness was acknowledged to the Association of Iron & Steel Electrical Engineers, which had evolved a set of general crane specifications giving a prominent place to safety features. Many of these features are included in the Safety Specifications given below.

These Specifications are intended primarily for use in ordering new cranes. It would not be practicable to apply their requirements fully to equipment already in place, which has been designed in accordance with the lower safety standards generally prevalent in the past.

Many of the provisions of these specifications, however, are applicable to all existing equipment, among which the following are of special importance: —

Footwalks, on Bridge Girders and Trolleys.
Warring Gong.
Protection of Gearing, Shafting, Couplings, etc.
Safety Switch on Main Line.
Enclosure of Live Electrical Parts.
Hoist limit.
Wheel Guards or Fenders.
Steel Hoisting Cables rather than Chains.

Safety Specifications for Electric Traveling Cranes

(1) *General Construction*

(*a*) Material and workmanship must be first class in every respect. All cranes shall be designed with the following factors of safety, based on the ultimate strength of the materials used when under full rated load stresses:

Parts subject to dynamic strains, such as gear shafts, drum shafts, gears, hooks, blocks, etc., not less than ten.

Hoisting cables, not less than eight.

Girders and other parts subject to static strains, not less than five.

* See Proceedings for April, 1912, Pages 177–185.

For journals and axles, the dimensions shall be increased until the bearing pressure and deflection come within safe and durable limits.

(*b*) Crane shall be of what is known as "All Steel" construction. No cast iron shall be used except for minor parts, such as drums, bearing brackets, caps and boxes, etc., where strength is not of primary importance. (When submitting bids, the builder is requested to specify all parts where he proposes using cast iron.) No wood or other combustible material is to be used in the construction of any crane.

(*c*) All bolts shall be through type, no studs or cap screws being used unless by special agreement; bolts to be suitably secured from turning, and equipped with approved lock-nuts or lock-washers.

(*d*) All wheels shall either be of rolled steel, or of cast-iron bodies equipped with standard steel tires, — no cast treads being used.

(*e*) Rails shall be fastened to girders by bolted clamps, so arranged that the bolts can be conveniently replaced if necessary. Suitable stops must be riveted to girders, to prevent creeping of rails.

(*f*) Steps or stairs with hand rails shall be used, wherever possible, in preference to ladders.

(2) *Footwalks* (See Page 177)

(*a*) Footwalks shall be placed in the following locations: —

Entire length of Bridge Girders on both sides (or) driving side.

Across both ends (or) one end of trolley at right angles to bridge walks.

Across side of trolley opposite bridge drive. (If there is only one walk on bridge; where there is a walk on this side of bridge, or one across end of crane runway that will serve the same purpose, this section may be omitted.)

(*b*) Footwalks shall be of substantial construction, rigidly braced so as to eliminate vibration, and built entirely of steel.

Width of main walks, — not less than 30″ from outer edge of walk to web of girder.

Width of trolley walks, — not less than 12″.

(*c*) Wherever possible, all walks should be so arranged that there will be a clearance of at least 6′ 6″ between floor of walk and overhead trusses or other structural members. Clearance between railing on bridge walk and nearest part of trolley, shall be not less than 18″.

(*d*) Footwalks should pass underneath and **around**, instead of **over** bridge motor, and may be reduced to a width of 20″ (clear) at point where it passes motor. (See Fig. 4, P. 177.)

(*e*) Each walk shall have a standard railing and toe-board at all exposed edges.

Railings shall be of riveted structural steel construction, with two horizontal members, and not less than 3′ 6″ high. Toe-board to be at least 6″ (net) in height.

Floor of walks shall be of checkered steel plate, not less than ¼″ thick. Flooring must extend from outside toe-board to bridge girder and be fitted neatly where any irregularities occur, so as to leave no openings through floor.

(3) *Operator's Cage*

(*a*) Operator's cage must be securely fastened to bridge girders, and well braced, to minimize vibration. It should be large enough to allow ample room for equipment and operator.

For 3-motor cranes, cage should be not less than 5′ 0″ x 6′ 0″.

For 4-motor cranes, cage should be not less than 6′ 9″ x 7′ 0″.

(*b*) Floor shall be of ¾″ impregnated asbestos board, on steel plate not less than ¼″ thick.

(*c*) Unless otherwise specified, cage shall be solidly enclosed with sheet steel or woven steel fabric, to a height of 3′ 6″ from floor. If not so enclosed, standard railing and toe-board must be placed around exposed edges.

(*d*) A safe and convenient arrangement shall be made to allow operator to pass from cage to footwalks and bridge girders. Where a ladder is used, it should preferably be inside cage, but in every case the arrangement must be such that there will be no danger of operator falling to ground when using it. (See Fig. 3, P. 177.)

(*e*) Floor of cage shall be extended on entrance side so as to form a landing, not less than 15″ wide; this landing to be equipped with hand-rail and toe-board of same construction as bridge walk.

Note. — Where there is a fixed platform at top of stairway or ladder, that will serve the same purpose (see Fig. 6, P. 181), this landing may be omitted, unless it is needed to comply with provisions of 3-d.

(*f*) An approved foot- or hand-operated gong shall be placed in a convenient location, and securely fastened, to eliminate danger of parts working loose and falling.

(*g*) Ladle and other cranes subjected to heat from below must have ⅛″ sheet-steel shield, six inches below bottom of cage floor.

(4) *Shafting, Couplings, Gears, etc.*

(*a*) All parts of crane must be readily accessible and so designed that it will not be necessary to remove any keyed part, or disturb any other shaft in order to change any shaft on the crane.

Fig. 1. Crane Switchboard with Apparatus for Dynamic Braking Hoist Control.

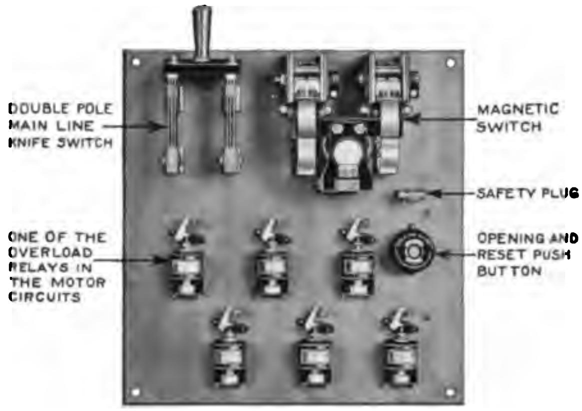


Fig. 2. Switchboard with Parts designated.

Dynamic Braking can be used for quickly stopping any heavy or rapidly revolving motor-driven machinery, where considerable momentum must be overcome.

Fig. 3. Crane with Enclosed Double-Deck Cage.

Note the arrangement of gear guards, also railed ladder leading from platform on side of cage to overhead foot-walk.

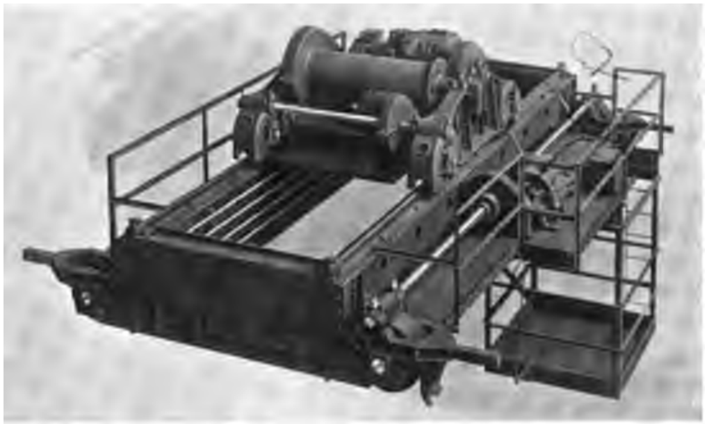


Fig. 4. Traveling Crane with Excellent Arrangement of Gear Guards, Walks, etc.

Note guards in front of bridge and trolley wheels, shield underneath trolley, gear guards, foot-walks enclosed solidly to girder, rolled steel trolley conductors, etc.

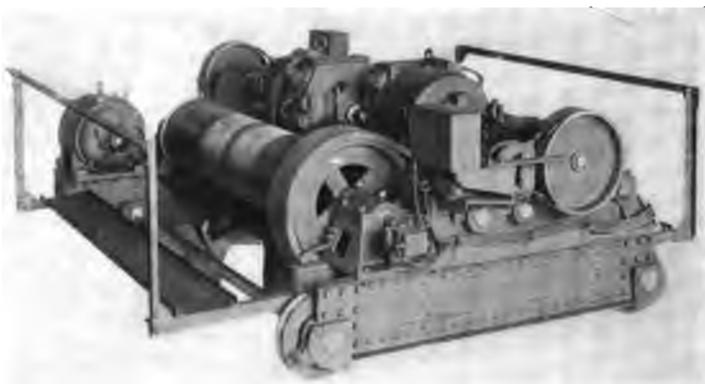


Fig. 5. Mill Crane Trolley with Railed Foot-Walks.

Note elimination of overhung gears in Figs. 4 and 5 and convenience with which wheels may be replaced.

(*b*) All hoisting shafting carrying gears, pinions, drums, or sheaves shall be of forged open hearth steel, the net required section being increased in diameter by not less than twice the depth of key seat. Over-all shaft diameter shall be in even eighths of an inch.

(*c*) All connections subject to torsion are to be pressed or shrunk on and keyed in place; press fits to be made with pressure of not less than nine (9) tons per inch diameter.

(*d*) Shafting and couplings shall be entirely enclosed, the covers being so designed that they are readily detachable, and supported in such a manner that they do not revolve with the shaft.

(*e*) Wherever possible, overhung gears must be eliminated. No split gears shall be used.

(*f*) All gears shall be encased with oil- and dust-proof covers; these covers to be conveniently arranged for inspection and lubrication, and strong enough to retain the whole gear, or any parts which might break and fall.

(*g*) Keys shall be secured in some approved manner, to prevent possibility of gears working loose. Unprotected keys must not be left projecting from ends of shafts, — they must be covered or otherwise protected.

(*h*) All bearings except those on motors, and M. C. B. type shall have approved screw feed compression grease cups. These cups to be located at points accessible to footwalks, and provided with extension pipes where necessary to bring them within easy reach of walks.

(5) Switchboard and Wiring, etc.

(*a*) The installation of switchboard, wiring and all electrical equipment, must fully comply with the requirements of the National Board of Fire Underwriters.

(*b*) With the exception of trolley conductors, all apparatus carrying electric current must be thoroughly insulated, enclosed or guarded, in such a manner that there will be no danger of accidental contact with live parts.

(*c*) Unless otherwise specified, switchboard shall be placed in rear of cage, and contain the following equipment (see Fig. 2, P. 177): —

Two Pilot Lights.

One D. P. Main Line Switch.

One D. P. Magnetically-operated Circuit Breaker, with an individual D. P. Overload Relay and Fuse for each motor on crane; Circuit Breaker to be so designed that it will open automatically if current supply fails, and remain open until closed by operator.

(*d*) Switchboard and its equipment shall be enclosed in asbestos lined steel cabinet, with swinging door arranged so it can be locked.

(*e*) In addition to the one on crane switchboard, there shall be a main line switch mounted above cage where it can be conveniently reached from footwalk. This switch must be so constructed that it can be locked in open position.

(*f*) All wiring must be placed in approved conduits, which should be continuous to switch boxes, etc., so that there are no bare terminals exposed.

(*g*) Unless otherwise specified, trolley conductors are to be soft steel bars or other suitable rolled steel sections, with tinned joints and good mechanical supports. They should preferably be located outside and above bridge girder, on side opposite bridge motor, in convenient relation to footwalk; in no case shall their location be such that they may be brought into accidental contact with hoist cable.

(*h*) Open type controllers to have asbestos lined steel guard over the moveable contact parts.

(*i*) Rheostats and resistance units shall be protected from accidental contact or mechanical injury, by suitable enclosure, — adequate provision being made for ventilation.

(6) Brakes

(*a*) Unless otherwise specified, each crane hoist shall be equipped with an approved system of dynamic braking. (See Fig. 1, P. 177.)

(*b*) Dynamic brake shall be supplemented by two magnetic holding brakes of approved type, either of which must be sufficiently powerful to hold rated load independently, under regular operating conditions. One of the holding brakes should be on armature shaft, the other on an intermediate reduction shaft.

(*c*) There shall be a foot brake for bridge travel, of ample capacity to control crane under full load, at full speed.

(*d*) All friction brakes must be of shoe or multiple disc type, so constructed that they will be equally efficient in either direction; no band brakes to be used.

(*e*) Brakes must be encased or guarded in such a manner as to eliminate danger of loose or broken parts falling to floor.

(7) Hoist Limit

(*a*) An approved normally closed limit device shall be provided for each hoist. This should preferably be tripped directly from hoisting block or hook, and **not** through screw contacts, with large reduction ratio. (See Page 179.)

Unless otherwise specified, dynamic braking must be employed in connection with hoist limit, to check speed of motor.

(8) Hoist Mechanism

(*a*) All hoists shall be equipped with approved steel cable, no chain being used; cable to be of plow

Fig. 1. Hoist Limit Device.

Fig. 1-A.

Fig. 2. Hoist Limit Device.

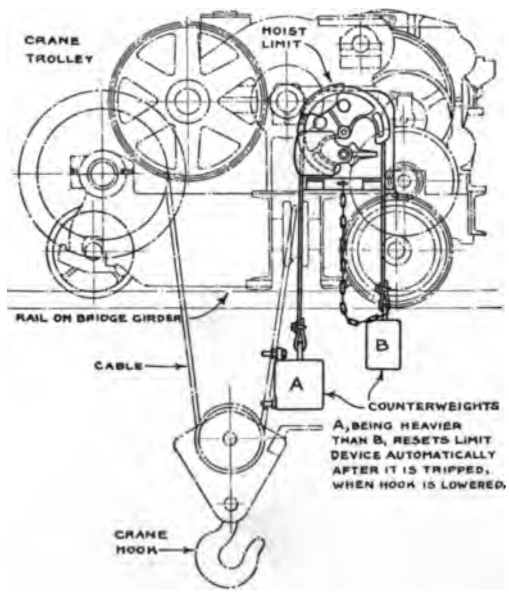


Fig. 2-A.

These illustrations show two standard makes of Crane Hoist Limits, both of which are operated directly from the hoisting block. This permits of accurate adjustment, which allows the maximum possible travel in hoisting. The dynamic braking principle is employed, automatically, to check drift of block when running light. Figs. 1 and 2 show the Limit Device, and 1-A and 2-A the respective application of the two devices to crane trolleys.

steel inside and crucible steel outside, or of all plow steel, — six strands, thirty-seven wires to the strand. Hemp core may be used for ordinary service, but core must be of soft iron where subjected to excessive heat.

(*b*) The pitch diameter of hoist drums and sheaves shall be at least thirty times the diameter of the cable. The drums must have flanges at each end not less than 1″ thick and projecting at least 2¾″ from body of drum.

(*c*) Drums shall be so designed that there will be not less than two full wraps of hoisting cable in the grooves when hook is at lowest position called for in specifications.

(*d*) Hook block shall be of an approved safety type, so arranged that it will lift vertically without twisting; hooks to be of forged steel construction, and provided with ball bearings.

(*e*) Bottom sheaves must be protected by close fitting guards to prevent rope from becoming misplaced.

(9) Bumpers and Wheel Guards. (See Pages 177 and 181.)

(*a*) Substantial bumpers, equipped with springs or other approved form of cushioning device, shall be provided at end of trolley travel. These bumpers must be securely attached to bridge girder, and not to rail.

(*b*) Where there is more than one crane on the same runway, suitable bumping blocks must be placed on end carriages or equalizing trucks, at each end of bridge girder, these bumpers to have springs or other approved cushioning device.

(*c*) Guards or fenders, of steel plate or forgings, shall be placed in front of each of the bridge truck and trolley wheels; these fenders to extend down on each side at least ½″ below head of rail, and to be rigidly secured in a position far enough in front of wheel to prevent danger of crushing a man's hand on rail.

(10) Miscellaneous

(*a*) Heavy lugs or brackets shall be placed on trolley frames and end carriages, where necessary to limit drop to 1″ or less, if a wheel or axle should break.

(*b*) Trucks shall be provided with adequate pads for use with jacks or wedges, when changing track wheels; cranes to be designed so as to permit changing wheels by simply relieving the bearings of the weight.

(*c*) A pan or flooring of steel plate, not less than $\frac{3}{16}$″ thick, shall be attached to trolley frame, so as to eliminate danger of objects falling from trolley to ground. (See Fig. 4, P. 177.)

(*d*) A plate giving rated capacity of crane shall be placed on the outside of each bridge girder.

(*e*) Unless otherwise specified, there shall be sand boxes, operated from the cage, and applying sand to both runway rails.

(*f*) A suitable tool box must be permanently attached at a convenient point in cage or on runway; this should be of sheet steel construction, and large enough to contain the necessary tools, oil cans, etc.

For cranes in outside service, the following additional provisions shall be made: —

Floor of footwalks shall be perforated with $\frac{11}{16}$″ drainage holes, spaced approximately 12″ centres.

Cage shall be enclosed with No. 18 ga. steel siding and 16 ga. roof. There shall be metallic sash windows on three sides of cage, windows in front and side opposite door to be full width of cage.

Where there are no members over crane suitable for attaching blocks, a structural steel outrigger shall extend across bridge girders, — of sufficient strength to lift heaviest part of trolley.

Outrigger to be located over bridge motor.

(11) Inspection

These features are to be subject to the approval of the ——— Company's inspectors, who shall be given an opportunity to inspect crane at any time requested.

Safety Requirements for Crane Installations

(*a*) Safe and convenient means should be provided for giving access to all cranes. For this purpose stairways are preferable to ladders. Stairways largely reduce the danger of falling when going to or from the crane, and at the same time they facilitate the handling of tools and other parts when repairs are being made. (See Fig. 2, P. 181.)

Where, for lack of room or any other reason, ladders are used, they should be rigidly fastened in place, and, if more than fifteen feet in height, they should be equipped with standard Safety Cages. (See Fig. 1, P. 181.)

(*b*) A footwalk should be provided along the entire length of runway, from which the crane can be reached at any point. This footwalk should be about on a level with the top of the runway girder.

While it is desirable to have footwalks on both sides of the runway, the principal need is met by a walk the full length on one side, and a short section on the other, from which repairs, such as changing track-wheels, etc., can be made.

Work of this kind is hazardous at best, and the arrangement should be such as to render the use of temporary scaffolding, with its added element of risk, unnecessary.

Where the crane is inside a building, the footwalk can usually be formed by filling in the space between the runway rail and the wall, with a steel

Fig. 1. Floor-operated Traveling Crane, with Foot-Walk and Repair Platform on Girders, Caged Ladders, and Walks Entire Length of Runway over Crane.*

Fig. 2. Stairway Leading to Crane Runway, with Enclosed Walk on Side of Building.*

Fig. 3. Bumper Riveted to Girder of Crane Runway, — with Wood Buffing Block.*

Fig. 4. Bumper on Crane Carriage, and Guard in Front of Track Wheel.*

Fig. 5. Spring Bumpers on Crane and Runway. (National Tube Company.)

Fig. 6. Stairway and Platform for Crane.*

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

plate. Unless sufficient clearance can be obtained to prevent danger of crushing persons between the bridge-truck and building columns, the walk should be carried outside the columns. (Fig. 2, P. 181.)

(*c*) A clearance of 6′ 0″ between the highest portion of the trolley on which persons may stand and overhead trusses, braces, roof supports, etc., is desirable. This clearance should never be reduced to a point where persons on the trolley could be crushed between it and the overhead members.

(*d*) Bumpers should be placed at the ends of crane runways; they should be of substantial construction, and securely attached to runway girder and not to rail. Bumpers should be equipped with springs, wood blocks or other suitable form of cushioning device, and should be arranged so as to clear fenders in front of crane wheels, satisfactorily. (See Page 181.)

(*e*) A switch should be provided on the runway, to cut off power from the trolley wires. This switch should be located where it can be conveniently reached from a runway, stairway, ladder, etc., and should be enclosed or guarded against accidental contact.

Rules for Crane Operators

In order to define the duties of crane operators and keep certain important safety considerations constantly before them, it is recommended that rules such as the following be framed and posted permanently in each crane cage.

"RULES FOR ELECTRIC CRANEMEN

NOTICE. — NO ONE BUT A REGULARLY AUTHORIZED OPERATOR IS ALLOWED TO USE ANY CRANE

1. When on duty, remain in crane cage ready for prompt service.
2. Never go on top of crane, or permit any one else to do so, without opening main switch and placing warning sign or lock on it; when you find this signal on switch, do not close same until you are absolutely sure there is no one on crane or crane runway who might be caught.
3. Before racking carriage or moving crane bridge, be sure that hook is high enough to clear all obstacles.
4. Under no consideration permit your crane to bump into another crane until you are positive that no one on the other crane is in a position to be injured.
5. Examine your crane every turn for loose or defective gears, keys, runways, railings, warning-bells, signs, switches, sweepbrushes, cables, etc., and report any defects found. Keep crane clean and well lubricated.
6. When crane is down for repairs, assist repairmen. After completion of any job, make sure that bolts, tools, etc., have been removed so that no damage to machinery will result when crane is started, and so that nothing can fall off crane. Keep tools, oil cans, and other loose objects in box provided for that purpose.
7. Do not carry load over men on floor. Use warning-gong to attract their attention.
8. Do not allow men to ride on load carried by crane, or on crane-hooks.
9. Do not move load without signal from proper man.
10. When handling heavy loads, particularly hot metal, test hoist-brake by throwing controller to "off" position after load has been lifted a few inches; if brake does not hold, do not move crane until it has been repaired or adjusted.
11. Do not carry objects up and down ladders; use rope for handling anything too large to go into pocket.
12. When leaving cage always open main switch.

Signature of Employer"

MISCELLANEOUS CRANES

Many of the foregoing provisions for electric traveling cranes are also applicable to miscellaneous types of cranes, such as ore unloaders, Gantry cranes, etc. The following additional precautions, however, should be observed for the types of cranes indicated below. The items relating to Gantry cranes and locomotive cranes are taken from the recommendations of the Standardization Committee of the National Safety Council, to whom indebtedness is acknowledged.

Gantry Cranes

All Gantry cranes shall be equipped with automatic warning bells.

The truck wheels of Gantry cranes shall be provided with guards or fenders.

Locomotive Cranes

Truck Frame. A clearance of at least 18 inches shall be provided between the bottom of the boiler and the truck frame.

A fence shall be installed on truck bed which, when extended, will prevent any one being caught between the boiler and the bed.

Outriggers and rail clamps shall be provided.

Fig. 1. Safeguards for Steam Shovel.

Fig. 2. Steam Shovel with Guards.*

Fig. 3. Foot-Walk and Cab Enclosure for Hot Metal Crane.†

An excellent arrangement of guards for the engine, gearing, etc., of a steam shovel or locomotive crane, is shown in Fig. 1. Doors in the guards make the enclosed parts readily accessible. A walk with handrail is placed on the side of this crane, the walk being hinged so it can be folded up against the cab when necessary.

In Fig. 2 attention is directed to the guard on propelling gear underneath the car, guards on hoisting engine gearing and crank, guard on shipper shaft gearing and pinion, and ladder full length of boom, giving access to sheaves. Grab-rails are provided along this ladder.

A stairway leads to the walk along runway in Fig. 3. The crane-cab is steel housed, the windows being provided with steel shutters which can be instantly closed in case of accident. Shortly after this protection was installed, a ladle of hot metal was dropped but the operator escaped without serious injury, as a result of the safeguards.

* Courtesy of Oliver Iron Mining Company.

† American Steel and Wire Company, subsidiary of United States Steel Corporation.

Automatic couplers shall be provided, and the truck frame shall be sufficiently long to give adequate clearance between the end of the boiler and a car coupled to the crane.

Boiler and Piping. Water Gage glasses shall be of approved reflex type, or provided with guards of wired glass or other construction which will eliminate danger to operator. (See Page 89.)

Drip cocks and exhaust pipes shall be fitted with long waste pipes so that the water will not fall on the deck plates.

Cab. Two doors in halves shall be provided, one on each side of cab.

Doors shall be hinged on rear side and swing outward.

Double acting latch shall be provided for each door.

Handholds shall be provided only at the doors.

Steps shall be provided only at the doors.

Boom. Indicator pointers showing safe load at any angle of the boom, shall be provided.

A guard shall be provided at the end of the boom, through which the cable may run, small enough to prevent the thimble on the cable coming in contact with the sheave wheel.

A guard shall be provided at the point where the boom cable passes over the idler, when the idler is within reach of man in the crane cab.

An electric indicator to warn cranemen in case of crane tipping shall be installed.

Signs. Table of capacities corresponding to size of crane shall be placed on inside of each cab.

"DANGER — KEEP OFF" signs shall be placed on each side of cab.

Jib Cranes

The pivot bearing at top of jib of swinging jib cranes, is often difficult to reach for oiling. Safe facilities for this purpose should be provided. In some cases it is possible to install overhead walks from which the bearing can be reached; in others a standard fixed ladder may be permanently attached to the jib.

Unless the boom can be lowered so its sheave bearings may be reached from the ground, similar provisions should also be made for oiling it.

It is important to protect the gears of jib cranes. Even though they are ordinarily hand-operated, they may be reversed by the load and seriously injure any one who is caught in them.

The load of jib cranes should not be allowed to run down by gravity unimpeded. If this is permitted, sufficient speed may be attained to cause the bursting of gear wheels or crank handle by centrifugal force. (A fatality from this cause is mentioned on page 77 of "The Prevention of Factory Accidents" by John Calder).

The use of wire cable rather than chains is also recommended for hoisting purposes on jib cranes. It may be difficult to make the sheaves for such cables as large as would be desired, and it is accordingly important to use extra or special flexible hoisting cable.

CHAPTER 19

ELEVATORS

THE fact that elevators are a type of equipment common to all industries does not wholly account for the large number of serious elevator accidents that occur; a further reason is undoubtedly the fact that, as frequently installed, elevators are one of the most hazardous types of equipment.

Elevators for passenger service, particularly those to which the public has access, are as a rule reasonably well protected. The freight elevators found in many factories and workshops, however, seem to be designed with cheapness rather than safety as the primary consideration.

The laxness in adopting proper safety precautions for freight elevators is undoubtedly due, to a considerable extent, to the belief that persons will not ride on them. This may be true in certain isolated cases, but as a matter of fact riding on freight elevators (with or without a load) is almost universal and is a very difficult practice to break up. It follows that the presumption is in favor of the riding, and this should be recognized and the equipment designed accordingly.

Since they are subjected to harder usage than passenger elevators, are more likely to be overloaded, and in general receive less careful attention after they are installed, freight elevators should have at least as high factors of safety, and as much consideration from the standpoint of securing adequate strength in their construction, as passenger elevators.

SPECIFICATIONS OR LEGAL REQUIREMENTS

In view of the important bearing of elevator equipment on human safety, certain standard requirements should be established for this equipment. Some States (notably Massachusetts) have adopted definite legal specifications stating in detail minimum safety requirements for existing elevator equipment and for new elevator installations.

Some elevator manufacturers have developed, and are prepared to furnish, equipment which is first class in every respect; in this as in many other lines, however, a few manufacturers are content to build cheaply at the expense of safety.

Definite safety specifications should accordingly be used in ordering new elevators. A simple and effective way to handle the matter is to specify that such equipment shall comply fully with the Massachusetts Regulations; or, the various safety features herein discussed may be embodied specifically in written specifications at the time an order for new equipment is placed.

The Massachusetts Elevator and Escalator Regulations, framed by a Board appointed by the Governor in 1913, undoubtedly represent the best safety requirements for elevators which have ever been developed. They are accordingly recommended for adoption by all those who are interested in safe elevator installations. Copies of the Regulations can be obtained upon application to the proper department of the Commonwealth of Massachusetts (Boston, Mass.), and they are not reprinted here, although references to some of their specific provisions are given as a matter of convenience.

CAUSES OF ELEVATOR ACCIDENTS

The chief causes of elevator accidents may be illustrated by the following list of injuries reported to the Massachusetts Industrial Accident Board during a period of one year. (See Table in Chapter 3.)

Cause of Accident	Character of Injury	
	Fatal	Non-fatal
Falling car	3	39
Caught between car and shaft	11	273
Person falling down shaft	5	72
Caught underneath or on top of car	3	53
Caught by fire hatch	2	11
Struck by falling object	0	30
Caught in machinery	0	45
Miscellaneous	9	513
Total	33	1,036

As indicating the seriousness of the elevator hazard, it may be pointed out that, while elevator accidents constituted only about 1% of the total from all causes for the year in question, elevators were responsible for 33 fatal accidents, or almost as many as those resulting from all hand labor, which caused 29,737 accidents with 37 fatalities. (See Chart on P. 11.)

While the sub-divisions in the above list are less complete than might be desired to bring out all important causes of elevator accidents, they undoubtedly indicate the most serious ones, and the following comments on these accidents, together with a brief discussion of means for preventing them, will be given.

Falling Car

Considering the fact that elevators are primarily hoisting devices of from one story to many stories in height, our first impression might be that falling cars would constitute the chief hazard from elevator operation. The accident record, however, shows that this is not the case; while falling cars caused about one tenth of the fatalities, they were responsible for only 4% of the total number of elevator accidents reported.

This does not mean, however, that the danger of falling cars may be disregarded. Such accidents, when they do occur, are usually of a very serious character, and every precaution should be taken for their avoidance. Among such precautions the following are of primary importance: —

1. Wire cables should be used. Chains and hemp ropes for hoisting purposes should be eliminated from all elevators on which persons ride. (See Massachusetts Regs., 38 and 94; see also Chapter 25.)
2. Two or more cables should be provided. (See Fig. 1, P. 187.) These should be attached separately in such a manner that entire dependence is not placed upon a single rod, bolt or other connection, failure of which may permit the car to fall.
3. Effective speed governors or slack cable safety devices which will stop the car in case the cables should break or become detached should be installed on each elevator. (See Figs. 1 and 4, P. 187; see Regs. 53 and 105.)
4. Thorough inspections of cables, safety devices, etc., should be made at regular intervals, written reports of the results of these inspections being kept on file. (For elevator inspection form, see P. 369.)

It is suggested that such inspections be made by the plant safety inspector where there is one, or by some one else designated for that purpose in each establishment. General inspections of the elevator equipment should be made weekly or bi-weekly, and the car safety devices should be tested at least once in six months by blocking up the car, slacking the cables, releasing the block and noting if the car is held effectively by the safety device.

Caught between Car and Shaft

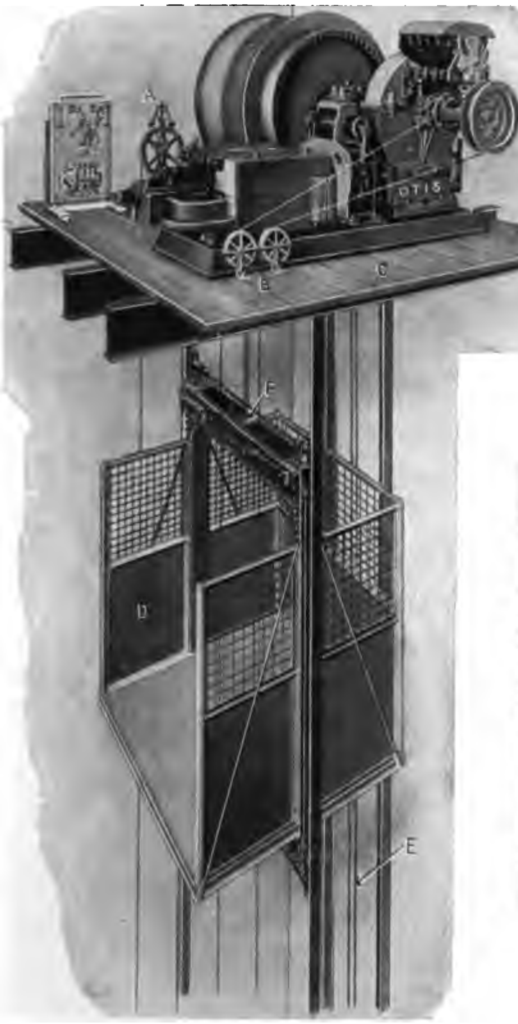
In the above list this form of accident was responsible for one-third of all fatalities and nearly one-third of all other injuries. Methods for avoiding such accidents are as follows: —

(1) Enclosure of unused sides of car. (See Section 2, Divisions B and C, of the Massachusetts Regulations.)

(2) Enclosure of shaft-way. (See Section 1, Divisions B and C, of the Massachusetts Regulations.)

(3) Elimination of shear-action between beams, floors or projections in the shaft-way and the floor of the ascending car. (See Regs. 13 and 73.)

Where the construction cannot be altered to eliminate such shear-points, bevel plates should be installed to minimize the danger. (See Fig. 1, P. 191.) Such bevels should also be installed



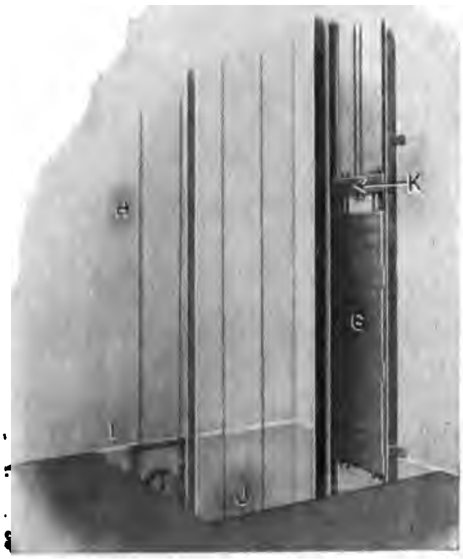


Fig. 1. Model Freight Elevator Installation.

In Fig. 1, safety features are indicated by letters, as follows: —

A. Speed governor connected to rope "H."
B. Guarded sheaves for shipper rope.
C. Solid top platform.
D. Car with three sides enclosed.
E. Multiple cables.
F and K. Socketed connections for cable to car and counterweight.
G. Counterweight sections bolted together.
H. Rope operating car safety device.
I. Guarded sheave for rope "H."
J. Pit at bottom of shaftway.

Fig. 2. Platform at Top of Shaftway.

Fig. 3. Wrecked Elevator Car.

Accidents have occurred from lack of sheave guards, permitting shipper rope to be misplaced. Guards "B" and "I" are accordingly very desirable.

Fig. 2 shows grating platform covered with wire netting (Mass. Reg. 21 e).

Fig. 3 shows an elevator platform wrecked by an object on the car catching underneath a beam. Solid bevel plates (preferably of metal, or metal sheeted) will prevent such accidents.

Fig. 4 shows safety device underneath car. If car should drop, speed governor "A" (Fig. 1) would grip rope "H," turning drum (Fig. 4) and tightening clamps on guides by means of screw and wedge action.

Fig. 4. Type of Safety Device to Stop Falling Car.

on the bottom of the car where the gate is open at the floor line, or the conditions are otherwise such that a foot might project into the shaftway at an entrance and be crushed by the descending car.

Shaftway Enclosure

Particular care should be taken to have the shaft enclosure smooth and rigid on sides where car entrances occur, since there is always danger of objects on the car slipping and striking the enclosure. Solid enclosure is especially desirable here, otherwise, the end of a truck-handle, rod, or other object being carried on the car, may catch in the enclosure while the car is in motion and cause an accident.

Entrances

Entrances should be located at the same side of the elevator shaft for all floors, wherever practicable, as this permits three sides of the car to be enclosed. (See Fig. 1, P. 187.) A definite element of danger is added when more than one side of the car is used, the maximum hazard being reached when entrances occur on all four sides of the car, thus preventing the use of any fixed enclosure whatsoever. On an elevator of this kind, serious accidents may be expected. If persons on the car slip or make any mismove while the car is in motion, there is no wall on the car to give support and they are likely to fall against the side of the shaft and be crushed between it and the floor of the car. Boxes, trucks, or other objects which are being carried, may also be caught between the side of the shaft and the car and wreck the car or cause other serious accidents. (See Fig. 3, P. 187.)

Persons falling down shaft

Accidents of this kind are usually due to the use of improper gates or of no gates at all. Wherever practicable, gates should be at least 5′ 6″ in height to prevent persons looking over top of gate and being struck by descending car. (See Fig. 5, P. 189.) 3′ 6″ is recommended as the minimum height for any gate, in order to prevent danger of persons falling over the gate and down the shaft. (See Regs. 15 to 17 and 75 to 77.)

Gates should be kept shut at all times except when the elevator car is at the landing. For passenger cars, an interlocking device which will not permit the car to be moved from an entrance until the gate or door is properly closed and latched, is desirable. (See Fig. 4, P. 189.)

Caught underneath or on top of car

Accidents of this kind are generally due to inadequate pits at the bottom of the shaft, or inadequate clearance at the top. (See Regs. 20, 21, and 80.)

The condition should be such that a person trapped in the pit or on top of the car cannot be crushed if an unexpected movement of the car occurs. A minimum clearance of three feet for both of these locations is recommended. (See Fig. 2, P. 189.)

Caught by fire hatch

Fire hatches are responsible for a material percentage of serious elevator accidents. The use of a fire hatch for common passageway is bad practice from a safety standpoint, since persons crossing the hatch may be intercepted by the moving car and injured by it or the hatch. All elevator hatches should be railed off and provided with gates; even though they are not regularly used for passage, persons may step out on them for various reasons (such as to note the position of the car) and be injured. Many accidents have resulted in this way. (See Regs. 15 and 75, *c* and *d*.)

Struck by falling object

Wherever practicable elevator gates should be solidly enclosed to the floor line to prevent objects rolling underneath them and falling down the shaft. (See Figs. 1 and 5, P. 189.) Where skeleton gates must be used the car should be provided with a cover. (See Fig. 3, P. 189; see Regs. 24*h* and 83*g*.)

The enclosure of the shaftway of elevators other than those of hatchway type is also instrumental in reducing accidents of the kind in question, by preventing objects piled near the elevator from falling down the shaftway. Top platforms (Figs. 1 and 2, P. 187) are of value in preventing parts of machinery located over the shaft from falling down it. (See Regs. 21 and 80.)

Fig. 1. Elevator Installation with Sign, Signal Button, 6′ Gate, Railing around Operating Mechanism, and Enclosure of Woven Wire Fabric. The latter offers practically no obstruction to the light.*

Fig. 2. Pit at Bottom of Elevator Shaft.*
Note clearance to prevent person in pit being crushed; also bumpers for car and counterweight.

Fig. 3. Hinged Cover for Elevator Car. This will release automatically if it should catch as the car descends.

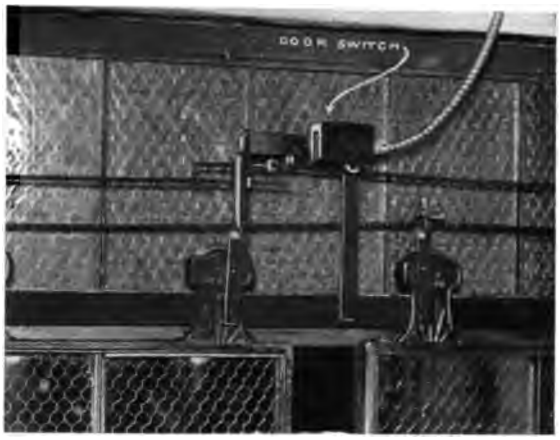


Fig. 4. Electric Door Switch. This insures doors being closed before car leaves landing.

Fig. 5. Telescoping Elevator Gate, for use where there is limited Head-Room.*

* Courtesy of American Steel and Wire Company.

Caught in machinery

Gearing, belting, shafting, and other mechanical parts of elevator equipment should be protected in accordance with the mechanical standards given in Chapter 17.

Miscellaneous

The miscellaneous accidents in the above list occurred from a wide variety of causes. Additional important provisions for avoiding such accidents are as follows: —

Signal bells should be provided so a proper signal can be given when the car is wanted. (See Fig. 1, P. 189; see Regs. 63 and 113.)

Locks should be installed on each car operated by a shipper rope, so the car cannot be started while it is being loaded or unloaded, by persons at other floors. (See Figs. 4 and 5, P. 191; see Regs. 55, 106, and 128.) An unexpected movement of this kind is likely to result in injury to the person using the car.*

Regular Operators are very desirable for all elevators, whether used for passenger or freight service. (See Division E of the Massachusetts Regulations.) This provision tends to minimize accidents, by preventing the handling of elevator equipment by those who are unexperienced or incompetent. It also practically eliminates danger of the car being started while persons are getting on or off, — a common cause of accident.

Where conditions do not justify the expense of a regular operator at all times, it is desirable to limit the indiscriminate use of the elevator by specifying a few individuals who are permitted to operate it, designating them by a special mark such as a cap or badge. Those persons should, of course, be carefully selected and thoroughly trained before they are permitted to run the elevator. A minimum age limit for elevator operators is desirable. (See Regs. 123*a* and 126.)

* One of several characteristic accidents which have come under the observation of the author may be cited by way of illustrating this point: — A workman left the elevator car at the top floor of a building while he went to get a heavy packing case. He returned, walking backwards, dragging the case after him. Meanwhile some one below had shifted the elevator, and the man and packing case fell down the shaft.

Riding on freight elevators should be prohibited wherever this can be done, and a notice to that effect should be posted. (See Fig. 1, P. 189.) Where riding is forbidden, however, it is most important to see that the rule is lived up to at all times and not disregarded, as is often the case. It is much better to permit riding and provide the necessary safeguards for persons using the elevator, than to adopt a rule against riding, which is not followed, and leave the equipment unprotected.

An emergency Power-Disconnecting Device should be used at all times when the equipment is being inspected or when repairs, etc., are being made, in such a location that an accident might result if the car were started unexpectedly.

This device may consist of a valve for hydraulic and steam elevators, a switch for electric elevators and a tight and loose pulley or friction clutch for belt-driven elevators. In each case a padlock or other suitable locking device should be provided, to be placed on this power-disconnecting arrangement when it is being used for any one's protection.

Warning chains should be attached to the bottom of the car on entrance sides, where gates are low enough to permit persons to lean over them. (See Fig. 1, P. 191.) The Massachusetts Regulations specify that such claims shall be not less than 30″ long, set not more than 6″ on centres, and secured to wood sills or cleats by 1″ staples. (See Regs. 57 and 108.)

Woodwork should be preferably eliminated from elevator construction, steel and other non-combustible materials being substituted. Steel construction is more stable, its strength can be more accurately determined, and it is less likely to get out of repair than wood.

Capacity Plates, preferably worded somewhat as follows, should be conspicuously displayed in freight elevators: —

**THE CAPACITY OF THIS ELEVATOR IS .... LBS.
DO NOT OVERLOAD IT.**

Many other desirable safety provisions are included in the Massachusetts Regulations to which reference has already been made.

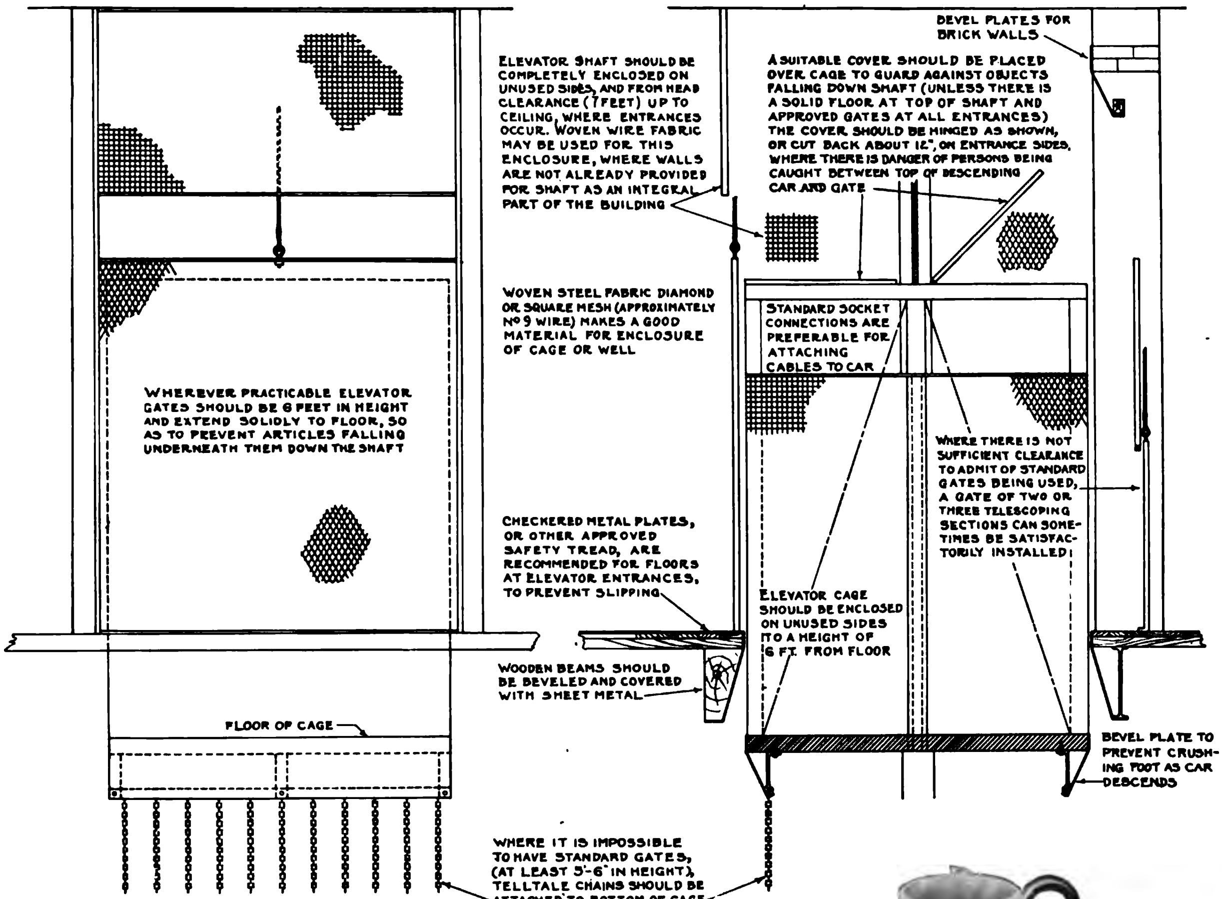


Fig. 1. Drawing illustrating Car and Shaft Enclosure, Tell-tale Chains, Bevel Plates, Cover over Car, etc.

Fig. 4. (Pat.)

Fig. 2.

Fig. 3.

Wired Glass Shaft Enclosure, Signal Buttons and Floor Indicator, collapsible Door on Car, Rubber Floor Mat, and Wire Screen to protect Fingers at Back of Car where Counterweight Passes.

Fig. 5.

Figs. 4 and 5 show cable lock. By removing key (Fig. 4) repairs can be made without fear of car being accidentally started.

CHAPTER 20

PUNCH PRESSES

PUNCH press work or metal stamping has always been classed with the extra-hazardous lines of industry. The insurance rate for metal stamping is some ten or twelve times that for ordinary machine shop work. Fatal injuries on power presses are almost unknown, but the frequent mutilation of hands and fingers is a serious matter to the insurance carrier, and to the workman who depends on his hands for support.

Causes of Press Accidents

An analysis of Power Press accidents will show they occur almost entirely from the following causes: —

1. Press repeating, — that is, taking a second stroke, where the operator expected the plunger to come down only once, thus catching him unawares.
2. Press stopped for adjustment, etc., taking an unexpected power stroke.
3. Fingers placed under plunger during ordinary operation, and not removed in time to avoid power stroke.

There are two types of power presses, viz., those which are hand fed, and those which are mechanically fed. Since the hazards in connection with these two types are essentially different, they will be discussed separately.

HAND-FED MACHINES

1. Repeating

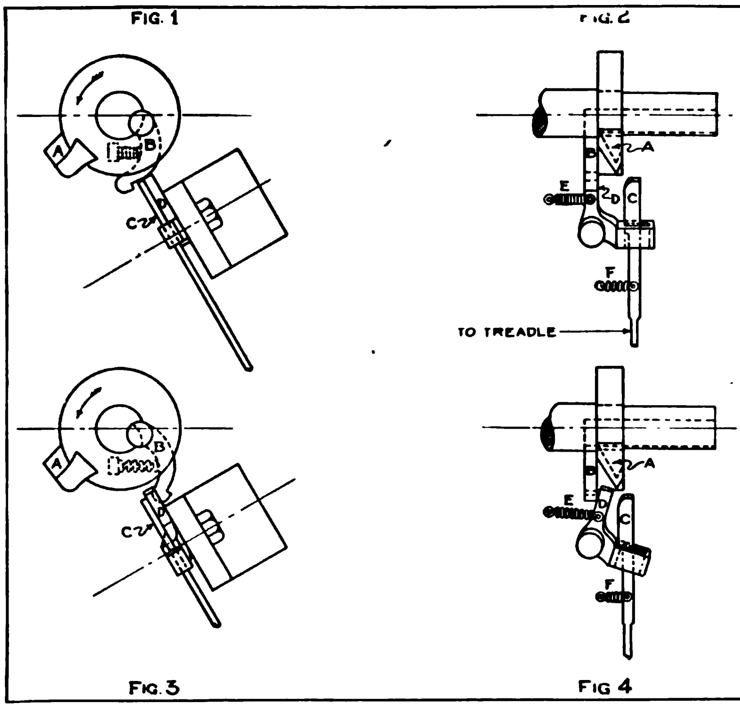
A poor principle of design commonly found in power press construction is that of depending on a friction brake to check the momentum of moving parts and stop the plunger between each operation. In many cases this brake is not released while the press is making a stroke, so it is subjected to constant wear whenever the shaft is turning. This soon causes the brake to become worn and loose, readily allowing the press to repeat or take a second stroke; the first evidence of this condition has often been the mutilation of an operator's hand.

Where such a serious possibility of accident exists, it is wrong to place dependence on a friction brake, which is bound to become loose and ineffective, sooner or later. While the claim is doubtless made at times that a press repeated and caused an accident when this was not the case, there is no doubt that repeating is a genuine cause of accidents, and presses are commonly arranged so that this can readily occur. Even though the friction brake is in perfectly normal condition, the press may repeat on account of the pulley "seizing" from lack of lubrication, or from the oil used to lubricate it becoming gummed, etc. This adds a second element of danger.

The solution of both these difficulties lies in the use of a positive mechanical stop, which will come into play in either of the above mentioned contingencies and prevent accidents from these causes. (See Drawings No. 113 and 122, P. 193, and Fig. 1, P. 194.)

Another cause of repeating lies in the fact that presses ordinarily are operated by a foot treadle, which is depressed to cause a power stroke, and which must be released immediately after the stroke is taken, or the plunger will come down a second time. The operator places a piece of stock under the plunger, depresses the treadle, releases the treadle (possibly removing the stock), and places another piece to be worked upon.

If this cycle of operations is carried through in exactly the right sequence, all is well. Where such an operation is repeated thousands of times a day, however, it is not strange that the foot sometimes loses synchronism, or gets "out of step" with the hand; it rests on the treadle a fractional part of a second too long, and the



OPERATION

PRESSING TREADLE OPERATES TRIP-ROD C WHICH TIPS LATCH D TO ONE SIDE OUT OF ENGAGEMENT WITH LEVER OF CLUTCH-KEY B.

CLUTCH-KEY B THEN SPRINGS OUT AND THROWS CLUTCH PROPER INTO ENGAGEMENT WITH BALANCE WHEEL (SEE FIGS 3 & 4)

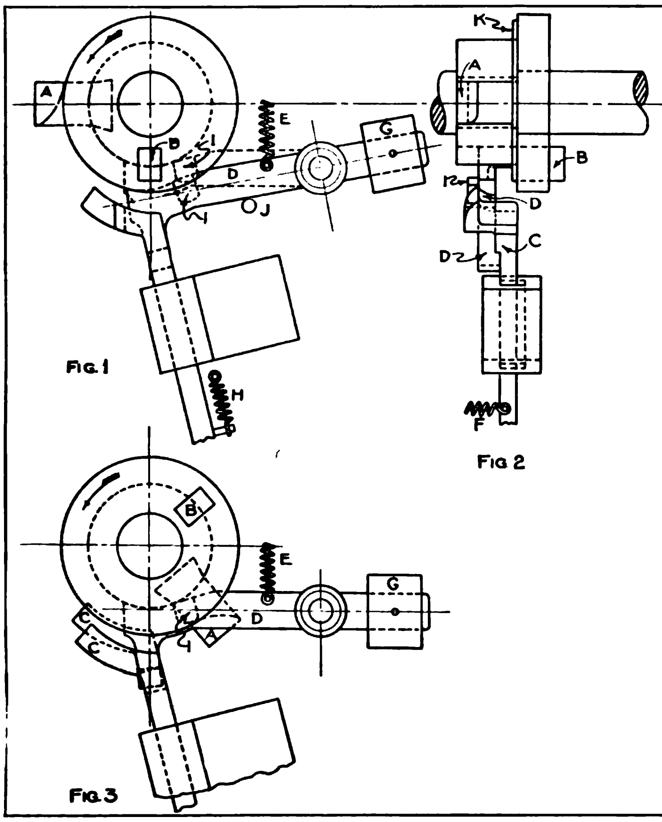
THE SHAFT NOW REVOLVES AND CAM A DISENGAGES TRIP-ROD C, BREAKING THE CONNECTION BETWEEN TREADLE-ROD AND LATCH D.

SPRING E THEN PULLS LATCH D BACK INTO THE FIRST POSITION. IN CASE OF FAILURE OF SPRING E, CAM A WOULD RETURN LATCH D POSITIVELY

HOOK ON POINT OF LEVER B WOULD STRIKE LATCH D, IF PRESS OVERTRAVELED, AND FORMS A POSITIVE STOP

SPRING F CAUSES TRIP-ROD C TO RE-ENGAGE LATCH D AS SOON AS OPERATOR RELEASES FOOT FROM TREADLE, AND CLUTCH IS THEN READY FOR THE NEXT OPERATION.

Drawing No. 113. Clutch-Operating Mechanism.* (Type 1.)



—OPERATION—

DEPRESSING TREADLE OPERATES TRIP-ROD C WHICH LOWERS LATCH D OUT OF ENGAGEMENT WITH SLOT OF CLUTCH-KEY B.

CLUTCH-KEY B IS THEN FORCED OUT BY FLAT SPRING K INTO POSITION TO ENGAGE THE BALANCE WHEEL. (SEE FIGS 1 & 2)

THE SHAFT NOW REVOLVES & CAM A DISENGAGES TRIP-ROD C, BREAKING THE CONNECTION BETWEEN TREADLE-ROD AND LATCH D.

WHEN SHAFT HAS REVOLVED A FEW DEGREES FURTHER, CAM A ENGAGES LUG I ON LATCH D, FORCING IT BACK INTO POSITION TO RECEIVE & DISENGAGE CLUTCH-KEY B FROM THE BALANCE WHEEL. (FIG. 3.)

COUNTER WEIGHT G SERVES AS A SAFE GUARD TO KEEP LATCH D IN POSITION. SHOULD SPRING E BREAK

TENSION SPRINGS F AND H CAUSE TRIP-ROD C TO REINGAGE LATCH D AS SOON AS OPERATOR RELEASES FOOT FROM TREADLE, AND CLUTCH IS THEN READY FOR THE NEXT OPERATION.

SHOULD THE FRICTION BRAKE BECOME LOOSE, OR THE BALANCE WHEEL "SIEZE", AND PRESS START TO REPEAT, THE CLUTCH-KEY B WILL STRIKE LUG I, AS SHOWN BY DOTTED LINES IN FIG. 1, AND THUS PREVENT PRESS FROM REPEATING.

Drawing No. 122. Clutch-Operating Mechanism.* (Type 2.)

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 2. Treadle-Disconnecting Device.*

Fig. 1. Clutch-Operating Mechanism.
(Type 3, Patented.)

Fig 1 shows a patented device combining the features of (1) positive stop (2) positive latch return, eliminating the use of springs in essential motions, and (3) treadle-disconnecting device. The positive stop is formed by the end of clutch-key D which revolves with the shaft. If, for any reason, the press tends to "carry over" and repeat, D (and consequently the shaft) is held by latch C. The latch return is made positive by latch-arm H, which comes in contact with cam G after the stroke of the press is about completed, moving latch C back into the path of clutch-key D which throws the clutch out of action. The treadle is disconnected by cam E striking the point of trip-hook B, causing it to spring outward, and release latch C.

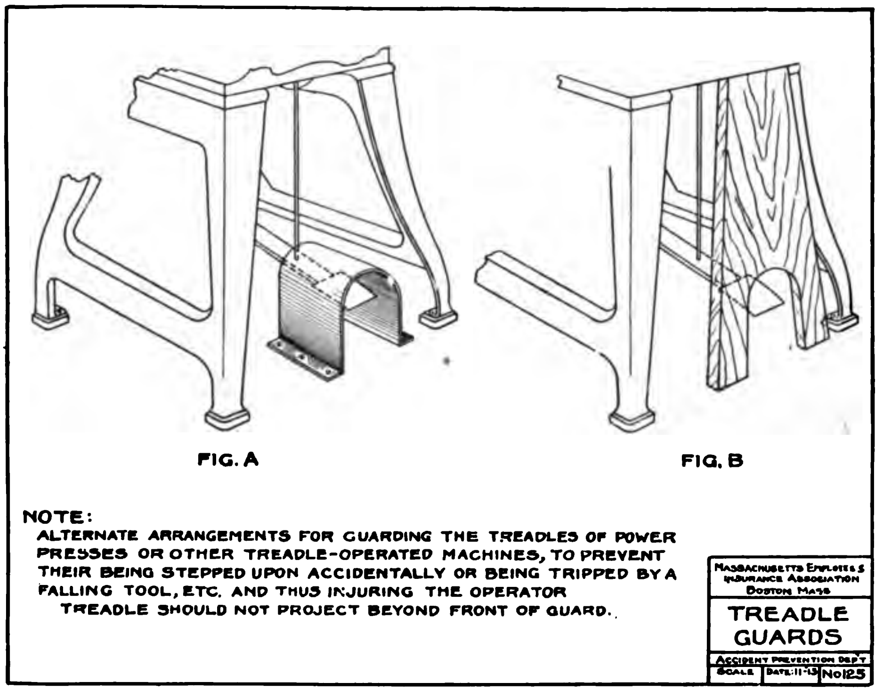


Fig. 3. Treadle Guards.

Fig. 2 illustrates another type of treadle, disconnecting device. When the treadle is depressed, hook D on treadle rod pulls down rod E, letting in clutch key and causing the press to take a stroke. Cam A which is attached to a collar on the shaft then depresses plunger C, forcing hook D outward and unlatching it. The press cannot take a second stroke until the treadle comes to its upper position, permitting hook D to re-engage.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

hand which reaches to remove the stock or to place a new piece is caught and crushed by the descending plunger.

This is a common cause of accident, but it can be eliminated by the use of a treadle-disconnecting device, — that is, an arrangement for entirely disconnecting the treadle from the clutch operating mechanism, between each stroke. This is readily accomplished by means of a latch or hook connection, which is knocked loose as soon as the press starts its power stroke. The treadle may then be held down indefinitely and it will not cause the machine to repeat; it must be released and allowed to come to its upper position before the press can be operated again. (See Drawings No. 113 and 122, P. 193, and Fig. 1, P. 194.)

Another cause of repeating is found in the use of springs in some essential part of the clutch mechanism, failure of which may cause the press to take a second stroke. Even under the most careful system of inspection and testing a defective spring may be used occasionally. If it is imperfect from the start, it may fail at any moment. Aside from this, a spring which was all right at first may become fatigued or strained by the constant succession of expansions and contractions, so that it breaks or stretches, and thus fails to perform its function at a critical time. Such an arrangement cannot be considered adequate, where a human hand may be lost through failure of the spring.

This danger can be avoided by the use of cams, counterweights, and similar positive mechanical actions, in place of springs. (See Drawings No. 113 and 122.) The hazard is especially great where the spring is in tension as it is then most liable to fail. A compression spring may be enclosed, so that it will react even though broken in two, but a positive motion is preferable to a spring in any form.

2. Unexpected Strokes while Press is stopped

It is common practice to have presses belted direct to the main driving shaft, so that the belt is still running on the fly-wheel when the press is stopped to make an adjustment or change dies, etc. This means that an accidental touch upon the treadle may cause the press to make a stroke, and as the operator depends upon its being stopped, he may have his hands directly underneath the plunger at the time.

One way to guard against such a possibility is to use an intermediate countershaft, with a tight and loose pulley or a friction clutch, arranged so that the belt to the press proper can be stopped when an adjustment is being made. (Fig. 3, P. 196.) This makes certain that the press is "dead" and accidental depression of the treadle cannot start the machine. Such a provision is required by law in some States.

Where this provision is not made, however, at the time the machinery is installed, it would be an expensive matter to put in a countershaft afterwards. This might even be impracticable, on account of the relative position of the machine and driving shaft.

As an alternative, it is possible to box in or guard the treadle in such a way as to prevent danger of its being tripped accidentally. One such accident was caused by a wrench falling from the table of the machine and striking the treadle; others have occurred through the operator himself accidentally stepping on the treadle. This can readily be guarded against by a shield such as is shown in Fig. 3, P. 194. Presses may also be equipped with a device for locking the clutch while dies are being changed, thus making it impossible to operate the clutch until the lock is released.

There is a further possibility, however, of the press making a stroke while it is shut down for adjustment, through the pulley seizing; this would be taken care of by the Positive Stop already mentioned.

3. Fingers under Plunger during Ordinary Operation

Accidents from this cause generally occur through a piece becoming misplaced, and the operator's attempting to adjust it after the press has started to make a stroke. Such accidents may also be caused by a temporary distraction of attention, and neglect to remove hands or fingers in time to avoid the descending plunger.

Fig. 1. Slide Feed.

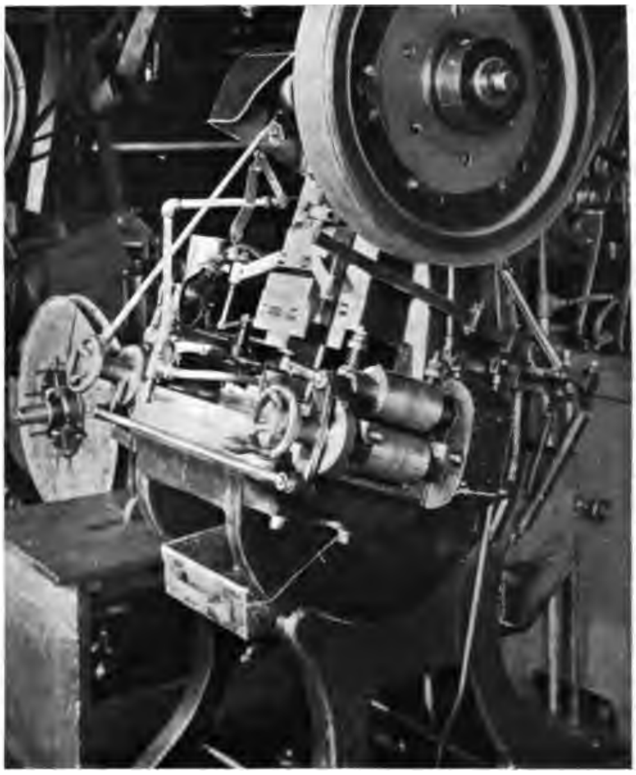


Fig. 2. Roll Feed, Fly-Wheel Guard, etc.*

Fig. 3. Countershaft Drives.

Fig. 4. Rotating Feed.*

In Fig. 1 a press equipped with slide feed is shown. Fig. 2 illustrates dial feed, and Fig. 4 a revolving table feed. Each of these devices permits the placing of stock at a safe distance from the plunger. Fig. 2 shows a roll-feed attachment. This machine also has a compressed air connection to the die, which removes the finished piece automatically. Note guarded feed-roll gearing, shaded electric light and disc guard for fly-wheel.

It is well to have belted presses driven from countershafting equipped with tight and loose pulleys as shown in Fig. 3. This permits the power to be completely disconnected from the press while adjustments are being made, dies changed, etc.

* Courtesy of Eastman Kodak Company.

There are several methods of guarding against this type of accident. One method consists in the use of a "sweep motion," which throws the hands away before the plunger can strike them. Such a device should be positively operated from a mechanical connection with the machine; it may also have a connection to the treadle, which causes the sweep to operate as soon as the treadle is started on its downward stroke. (See Pages 198 and 199.)

A second method consists in arranging the tripping mechanism so that it will be operated by hand instead of by foot, and so that the use of *both* hands is required. (Figs. 2 and 3, P. 198.)

A third method for preventing this class of accidents embodies the use of a shield or gate connected to the operating treadle so that it lowers in front of the work when the treadle is depressed slightly. This device entirely shuts off access to the table before the press is tripped; and may be adjusted so that the thickness of a finger underneath the gate prevents the press from operating. (Figs. 3, 4, and 5, P. 199.)

A fourth method for protecting fingers during ordinary operation is illustrated in Fig. 4, Page 201. This device has a light horizontal rod across the front of the press, which is lifted by the operator's arm each time he reaches forward underneath the plunger. To this rod is attached a bar which interlocks with a stop on the treadle rod, thus making it impossible to trip the clutch while the arm is in this position. If the operator should depress the treadle before reaching forward, the stop on the treadle rod would interfere with the interlocking bar, thus making the swinging rod rigid and checking the movement of the operator's arm.

It will be noted that these devices are all intended to accomplish the same purpose, but do so in different ways. They are all reasonably effective, if kept in proper adjustment, and may be considered as alternatives which are about equally satisfactory.

In many kinds of press work the material handled is comparatively thin (say $\frac{1}{4}''$ or less in thickness). In such cases it is often possible to provide a fixed guard, consisting of a bar or plate enclosing the space underneath the plunger. This guard should be placed at such a height that the stock will just slip underneath it, without leaving sufficient space for a finger to enter (say $\frac{3}{8}''$ or less). Where it can be installed this guard is an acceptable substitute for the three already described; in fact, it is superior to them in some respects, being more positive. (See Page 201.)

Placing and Removal of Stock

Every operation which requires the press attendant to place his or her hands underneath the plunger of the machine introduces a certain element of hazard. It is accordingly desirable to reduce this practice to the minimum. One way of doing so is to provide tools or mechanical means for placing the stock underneath the plunger and removing it, so that the operator does not do this with the fingers.

Sometimes the work is pushed through the die automatically; in other cases it is possible to provide a mechanical "pick-off" (Fig. 5, P. 202) which operates without the use of hands; for other classes of work, some form of pincers, or wooden or metal hand tool may be used. (Figs. 1, 3, and 4, P. 202.) Compressed air devices have also been employed for blowing the stock to one side, and vacuum arrangements may be adopted for picking it up. (Fig. 2, P. 196, and Fig. 2, P. 202.)

Different kinds of work require different treatment, but some one of these various methods can be used in almost any case, and where this is done the accident hazard is definitely reduced.

Dies should also be cut out at the front, so as to leave as much clearance as possible.

Mechanical Protection

The above outline covers the special hazard in connection with the operation of hand-fed power presses. In addition to this there are the common mechanical hazards, which should be safeguarded wherever they are encountered on power presses. This should include the protec-

Fig. 1. Horizontal Sweep-Motion for Power Press.

Fig. 2. Two-Handed Operating Arrangement.

Fig. 3. Two-Handed Operating Device. (Pat.)

Fig. 4. Rising Sweep for Foot Press. (Pat.)

Fig. 5. Horizontal Sweep for Foot Press. (Pat.)

Fig. 1 shows a device in which a horizontal bar sweeps across the table each time the press takes a stroke, thus pushing away a hand which might be left under the plunger accidentally.

Figs. 2 and 3 show devices requiring the use of both hands to operate the clutch; this removes the hands from the danger zone before the press starts.

Accidents occur on foot presses as well as on those which are power-driven; after the "kick" is once underway, the plunger of a foot press descends as surely as if it were a belted machine, and with sufficient force to crush a finger or hand. It is accordingly desirable to protect the hands of foot-press operators. The devices illustrated in Figs. 4 and 5 throw the hands out of the way before the plunger descends; in one case a rising sweep motion is used, in the other a horizontal sweep.

The solid fly-wheel on press shown in Fig. 1 eliminates danger of any one being injured by getting an arm through the spokes of the wheel, which may occur on unguarded spoked wheels.

Fig. 1. Sweep for Drop Press. (Pat.)

Fig. 2. Rising Sweep for Power Press. (Pat.)

Fig. 3. Automatic Safety Gate. (Pat.)

Fig. 1 shows a drop press equipped with a " sweep motion " operated directly by the falling weight. This device can be rotated out of the way while making adjustments.

Fig. 2 shows a guard which rises as the plunger starts to descend. After the stroke the guard drops down to a horizontal position.

Fig. 3 illustrates a device in which a guard or gate comes down in front of the table each time before the press takes a stroke. It is operated from the treadle, and can be adjusted so that the thickness of a finger underneath the guard will prevent the machine from tripping.

A good device is shown in Figs. 4 and 5. The guard itself is used to trip the press, being pulled down by the bar across the front.

Fig. 4. Press tripped by Safety Gate.

Fig. 5.*

* Courtesy of General Electric Company.

tion of gears, sprockets, chains, belts, fly-wheels, and the elimination of projecting set screws, bolts, keys, etc., from revolving parts. (See Fig. 2, P. 196; Figs. 1 and 2, P. 200; Figs. 4 and 5, P. 199.)

MECHANICALLY FED MACHINES

As already mentioned, the foregoing discussion has to do particularly with hand-fed presses. Machines which are equipped with mechanical feed are much safer to operate, from the fact that they do not involve much work requiring the hands of the operator to be placed underneath the plunger.

There are various types of mechanical feed in which the operator merely starts the stock, and the machine continues to work automatically until the piece runs out. Among these might be mentioned Roll or Ribbon Feed (Fig. 2, P. 196), Hopper Feed, Gravity Feed, etc.

Other types of mechanical feed, which are equally desirable from the safety standpoint, have a sliding or revolving action which permit the operator to place the work in position at a safe distance, and it is then carried under the plunger by mechanical means. Under this head may be classed Dial Feed (Fig. 5, P. 202), Slide Feed (Fig. 1, P. 196), Chain or Conveyor Feed, Rotating Feed (Fig. 4, P. 196), etc.

The principal danger in connection with mechanically fed machines occurs at the time when the operator is making adjustments or changing dies. If, for any reason, the press takes a stroke at this time, serious injury may result. Provision should accordingly be made for positive stop (to guard against pulley seizing), and treadle protection as already described.

It may also be desirable to place a guard or shield in front of the plunger while the machine is running, to avoid danger of an operator slipping and throwing out a hand in such a manner as to be caught underneath the plunger.

The mechanical protection of gears, belts, fly-wheels, etc., should, of course, be applied to machines having mechanical feed as well as those which are hand fed; feed rolls should also be protected.

SUMMARY

This scheme of protection may be summarized as follows: —

Hand-fed power and drop presses should comply with items 1 to 7, inclusive.

Mechanically fed power and drop presses need only comply with items 5, 6, and 7, also with item 3, unless condition 5–a or 5–b is present.

Foot presses need only comply with 1–a, 1–b, 1–d, or 1–e.

(1) **Protection of fingers while feeding stock**

For this purpose one of the following alternative arrangements is recommended: —

a. A fixed guard or enclosure around bottom position of plunger so arranged that a finger cannot go under plunger while feeding stock. (Page 201.)
b. A positive "sweep motion," mechanically operated, which throws the hands out of the way as the plunger descends. (Pages 198 and 199.)
c. "Two-handed" operation of the press, — that is, hands used instead of feet to trip the press, the simultaneous action of *both* hands being required. (Figs. 2 and 3, P. 198.)
d. A guard or gate in front of the plunger, which closes automatically each time before the power stroke is taken. (Figs. 3 and 4, P. 199.)
e. A clutch-interlocking device, manipulated by the operator's arm. (Fig. 4, P. 201.)
f. The use of tweezers or other approved tools for placing stock under the plunger, which do not necessitate the operators' bringing hands within 3″ or less of plunger while feeding the machine. (Fig. 1, P. 202.)

(2) **Treadle-Disconnecting Device** (not required for machines which are operated with fixed plunger guard only, as described in 1–a).

Each press equipped with some form of treadle-disconnecting device which will prevent a press from taking a second stroke until the treadle has been released and allowed to come to its upper position. (Pages 193 and 194.)

(3) **Positive Stop** (not required for machines which are operated with a fixed plunger-guard only, provided such machines are individually motor driven as specified in 5–a, or equipped with friction clutches or loose pulleys as specified in 5–b).

Each press provided with a positive mechanical stop which will prevent the press from taking a second stroke when the friction becomes worn or loose, or when the pulley seizes, etc. (Pages 193 and 194.)

Fig. 1. Grill-Work Plunger-Guard.*

Fig. 2. Fibre Plunger-Guard for Power Press.*

Fig. 3. Fibre Guard for Foot Press.*

Fig. 4. Arm-Operated Safety Device. (Pat.)

Figs. 1, 2, and 3 illustrate a simple and positive type of power press protection. This consists of a fixed guard located at such a height (preferably not more than $\frac{3}{8}''$) as will not permit a finger to pass underneath it. These guards are so constructed as to enable the operator to see the work, at the same time giving good protection.

Those shown in Figs. 2 and 3 are made of translucent fibre, which allows the light to shine through.

An interlocking device is shown in Fig. 4. This locks the treadle rod when the operator's arm is forward, as shown in the picture, and locks the horizontal swinging rod when the treadle is depressed.

Note also the guards for belts and pulleys of machines shown in Figs. 1, 2, and 4.

* Courtesy of Eastman Kodak Company.

Fig. 1. Use of Pneumatic Tool.*

Fig. 2. Automatic Air-Blast to remove Stock.*

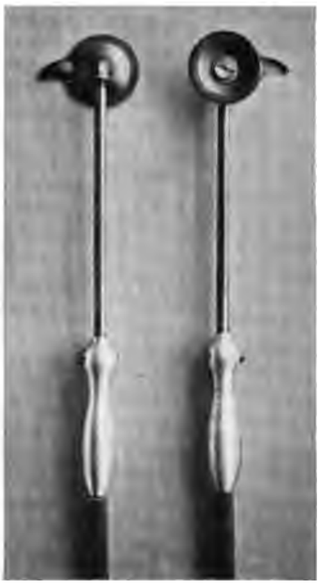


Fig. 3. Pneumatic Tool.*

Fig. 4. Tool caught in Press.*

Fig. 5. Automatic Pick-Off and Dial Feed.

These photographs illustrate safe ways of removing finished stock from a press. Fig. 1 shows the use of a suction tool, illustrated in detail in Fig. 3; the lifting pad is of rubber, the exhaust being controlled by a thumb-operated valve.

Fig. 2 illustrates a compressed air nozzle which blows the finished piece and scrap off the table. It is controlled by an automatic valve, giving a puff of air after each stroke of the plunger.

*** Courtesy of Westinghouse Electric and Manufacturing Company.**

(4) **Non-dependence on springs** (not required for machines which are operated with a fixed plunger-guard only).

The use of springs in the clutch and treadle-operating mechanism should be such that the press would not take a second stroke on account of the failure of any spring. This may be accomplished by using cams, counterweights, or other positive mechanical actions, instead of, or in combination with, springs. (Pages 193 and 194.)

(5) **Accidental tripping while changing dies, etc.**

Accidents from this source may be guarded against in one of the following ways: —

a. Where presses are individually motor driven, and electric power is shut off from the driving motor while dies are being changed and while adjustments or other operations necessitating hands being placed beneath the plunger are under way.

b. Where presses are provided with tight and loose pulleys and locking belt shifters or friction clutches in addition to the ordinary clutch-operating mechanism, these pulleys or clutches being placed on a countershaft and used to shut off power from the machine while dies are being changed, etc.

c. Where foot treadles are used, and the treadle of each machine is enclosed so as to avoid danger of striking it accidentally with a foot or falling object and thus causing the press to take an unexpected stroke. (Fig. 3, P. 194.)

d. Where an efficient clutch-locking device is provided for use while changing dies, etc., which will make it impossible for the clutch to operate and cause the press to take a stroke.

(6) **Removal of stock**

Accidents from this source may be avoided by the use of mechanical means for removing stock, such as an automatic pick-off, air blast, etc., also by the use of other methods which do not necessitate the operators placing hands underneath the plunger. (Page 202.)

(7) **Mechanical protection**

Feed rolls, gears, sprockets, belts, fly-wheels, set screws, etc., to be protected in accordance with general mechanical standards.

It will be noted that the above system of protection includes a safeguard for practically every danger in connection with power-press operation, except that caused by actual breakage or working loose of parts. Where it is fully carried out, accidents on this hazardous type of machine will be almost eliminated.

Some of the devices mentioned have already been used by various manufacturers, but taken separately they only affect a fractional part of the hazard. Combinations such as those mentioned at the beginning of the Summary are essential to secure the full value in accident reduction.

CHAPTER 21

MACHINE SHOP AND BLACKSMITH SHOP EQUIPMENT

MACHINE SHOP EQUIPMENT

THE hazard of exposed gearing has been recognized by machinery builders for some time, and the gears of modern machine tools are usually well protected. In purchasing new equipment, however, it is desirable to cover this and other mechanical hazards by definite specifications, such as the following, in order to have a clear understanding that the builder must furnish the necessary safeguards: —

Safety Specifications

General. (This clause applies to all machines.)

All gearing shall be *completely enclosed* with substantial cast-iron or sheet-metal covers, so designed as to make the parts within readily accessible. All couplings, set screws, keys, bolts, etc., in revolving parts shall be countersunk or covered in such a way as to eliminate danger of accident. Unused portions of exposed keyways shall be filled so as to present a smooth surface.

In addition to the above general specifications, the following provisions shall be made for the machines designated: —

Planers. Planer-beds shall be substantially covered with cast-iron or steel plate. The latter, if used, shall be not less than ⅛″ in thickness. (See Figures 1 and 2, Page 205.)

Drills. Wherever possible, counterweights should be placed inside the vertical columns of drill-presses. Where this cannot be done, a guard or enclosure shall be provided, to retain the weight in case the supporting chain or rope should break. (See Figure 2, Page 210.)

The belts of multiple-spindle drills shall be guarded across the front, where a breaking belt might endanger the eyes of the operator if unguarded. (See Figure 4, Page 210.)

Lathe Dogs shall be of safety type, having no projecting set screw or other part on which clothing might catch and cause accidents. (See Page 209.)

Additional safety precautions along the following lines should be taken for the protection of machine tools: —

Belts and Pulleys of individual machines should be guarded in accordance with the general standards outlined in Chapter 17. Where lathes are equipped with belt-shifters of the construction indicated in Figure 3, P. 164, the bar which supports the lower shifter-fork, together with the fork itself, practically eliminates danger of persons being caught between the belt and pulley. Some concerns have considered it desirable, however, to add another enclosure, as shown in Figure 1, Page 207.

Belt-Shifters. All cone pulley machines should be provided with suitable belt-shifters. (See Page 207.) Machines having tight and loose pulleys should be equipped with locking shifters, to prevent the belt creeping from loose to tight pulley. (See Pages 163 and 164.)

Counterweights of planers or other tools should be suitably enclosed or guarded. (See Figures 1 and 2, Page 158.)

Lathe Chucks or face-plates, having projecting set screws or other parts on which clothing might catch, should be protected. A good form of guard consists of a band hinged to the back of the lathe frame so that it can be swung out of the way when not in use. (See also Figure 2, Page 209.)

The cutters of milling machines should be protected by suitable guards wherever practicable. (See Figure 3, Page 205.)

Chip Guards should be furnished for use on shapers, lathes, and other machines, as needed. These guards are particularly desirable where such metals as tool-steel, bronze, etc., are being worked, since chips of these metals are liable to fly and injure the eyes of operators where guards are not in use. (See Figure 7, Page 205.)

Files should have handles, to protect the hands of men using them from the sharp ends of the files.

Reciprocating Tables, etc., of planers, shapers, and other machines, should not be permitted to travel so close to walls, columns, or other fixed structures as to make it possible

Fig. 1. Planer-Bed enclosed, to eliminate Danger from the Reciprocating Table.* Note also Belt Guard.

Fig. 2. Man with Hand crushed between Table and Ribs of Planer-Bed.

Fig. 3. Guarded Milling Cutter.*

Fig. 4. Bench Miller with Guard.†

Fig. 5. Telescoping Guard for Planer Table.‡

Fig. 6. Guards for Stock of Turret Lathes. (American Steel and Wire Company.)

The guard shown in Fig. 5 protects the space covered by travel of planer-bed.

The chip guard (Fig. 7) can be used on tool holders of shapers, lathes, etc., to protect eyes of operators.

Fig. 7. Chip Guard. (Pat.)

* Courtesy of United Shoe Machinery Company. † Eastman Kodak Company. ‡ Boston Elevated Railway Company.

for any one to be caught and crushed. A clearance of not less than 18 inches (preferably 24″ or more) should be provided between such reciprocating parts and any fixed objects.

Care should be taken at all times to avoid placing castings or other heavy objects close to such machines, where persons might be caught between the object and the moving table. A good table-guard, which adjusts itself automatically to lengthened planer travel, is shown in Figure 5, Page 205.

In using a drill press the work should always be bolted down or otherwise securely fastened in place, since accidents frequently result from the piece turning with the drill after the latter has passed through.

Emery and Abrasive Wheels. (See Chapter 23.)

BLACKSMITH SHOP EQUIPMENT

Hammering Tools

In blacksmith shops the principal hazard is that of flying particles from hammering tools (sledges, chisels, punches, etc.), the heads of which have become burred or "mushroomed." Particles from tools in this condition are liable to break off under the impact of a blow, and fly with sufficient force to destroy an eye, or even to pass through clothing and into the flesh. (See Figures 3 and 6, Page 376.)

It is possible, by constant watchfulness on the part of men using hammering tools, to keep them dressed at all times so that there is no danger from this source. It is well to have such tools inspected approximately once per week, to see that they are being kept in good condition. The burred edges may be carefully broken off, they may be ground off on an emery wheel, or they may be heated and removed by dressing.

In this connection the heat treatment of hammering tools is worthy of special consideration. If they are hardened slightly, the tendency to "mushroom" is materially reduced. Care must be taken, however, to avoid getting the tool too hard, as it then becomes brittle, and pieces may break from the head when it is apparently in perfect condition. There is a point where the tool is neither too hard nor too soft, but no definite standard of temperature can be laid down, since different grades of iron require different treatment. By practical tests, an experienced blacksmith should be able to determine when the right condition is reached for the particular stock on which he is working.

For heavy hammers (say those weighing twenty pounds or over) it will be found advantageous to make the striking face rounded or convex. (See Figure 1, Page 211.) This tends to "centre" the blow and prevent the hammer from twisting or turning in the hands of the man using it. Such twisting is liable to occur with a flat-faced hammer, if it does not strike fairly, causing an unpleasant shock, or even breaking the handle of the hammer.

Hammer handles should be inspected at regular intervals, to see that they are perfectly sound. If a handle becomes split, it may open when a blow is struck, and pinch or lacerate the hand of the man using it. Since the blacksmith's hands are exposed to more or less grime and dirt, there is considerable danger of even a slight wound of this kind becoming infected.

Accidents may occur in blacksmith shops from heads coming off the handle, or from the handle breaking and permitting the head to fly. (See Figure 2, Page 211.) In order to strengthen the head and prevent its spreading or breaking across the eye, the common tendency of blacksmiths is to make the opening so small that the handle is necessarily weak. Standard dimensions should be adopted which will insure a reasonable degree of strength in the handle. Those given in Figure 1, Page 211, may be taken as representing good practice.

The eyes of hammers should be "belled," as indicated in the drawing, so as to permit the handle to spread when a wedge is driven into it.

Where steam hammers are used, and where chipping is done, suitable screens should be erected to protect men who are working adjacent to the hammers, and to guard passageways which are in close proximity to them. (See Figure 1, Page 376.)

Men doing such work as chipping, grinding, babbitting, etc., should be required to wear goggles or face masks. (See Chapter 48.)

Fig. 1. Guarded Lathe.

Fig. 2. Lathe-Protection.*

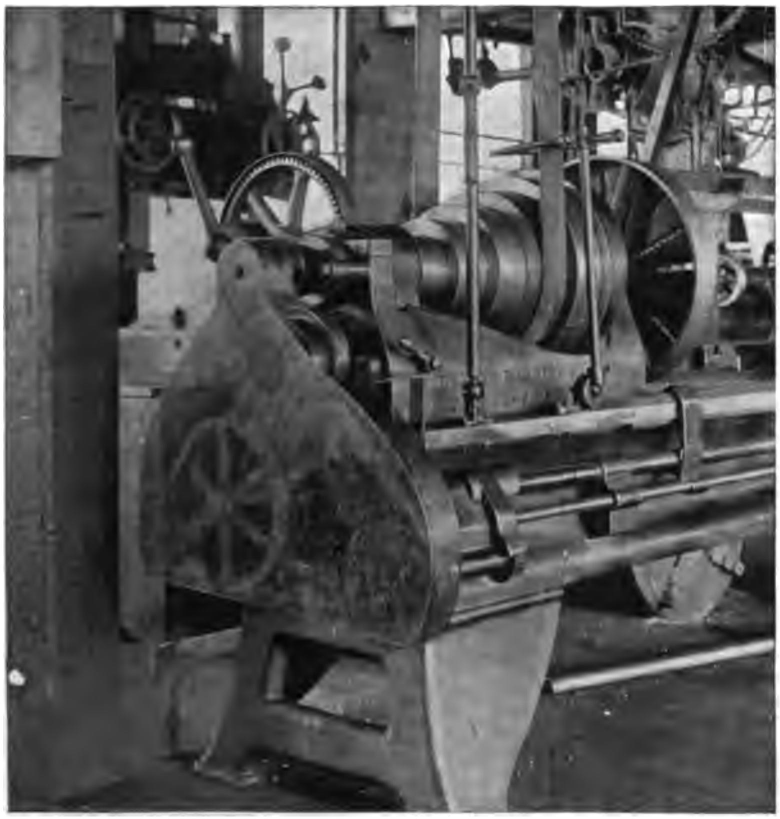


Fig. 3. (Courtesy of Ludlow Manufacturing Associates.)

These illustrations show different types of lathe-protection. It is well to completely enclose the back gears, as shown in Fig. 2, to prevent any possibility of persons being injured by the arms of the gear, or caught by the gears underneath the guard.

Each of these lathes is equipped with a safety cone pulley belt-shifter. In Fig. 1 the belt is shifted on the lower cone by a sliding fork, and on the upper cone by a similar device operated by cords passing over pulleys and hanging within reach of the operator; the handles on these cords can be seen at the upper edge of the photograph. In the other cases the belt is shifted on the upper cone by means of the vertical rod. (See Page 164.)

* Courtesy American Steel and Wire Company, subsidiary of the United States Steel Corporation.

Fig. 1.

Fig. 2.

(Courtesy of Fitchburg Engine Company.)

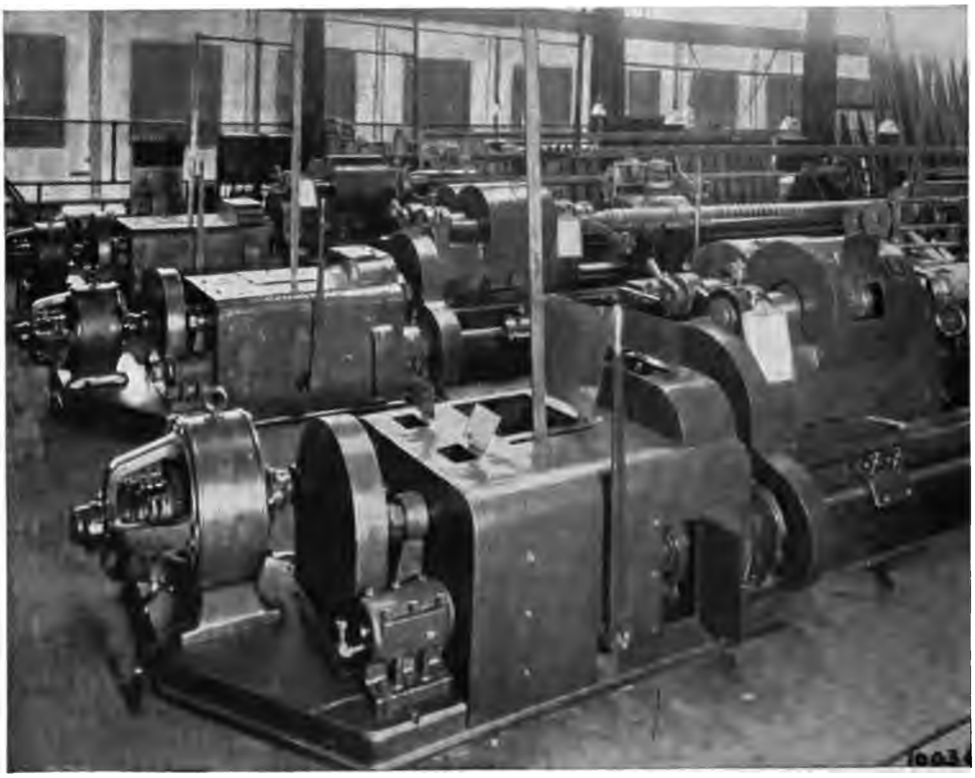


Fig. 3. (Courtesy of Westinghouse Electric Company.)

Figures 1 and 2 show an ingenious guard for change-feed lathe gearing where the machines are placed close together. This guard permits easy access to the gears, while thoroughly protecting them on the exposed side.

Figure 3 illustrates an excellent arrangement of gear and belt-guards. Note particularly the various doors and openings which render the gearing and oiling places readily accessible, while at the same time the gears are completely protected.

In Fig. 1 the operator has his hands on the cone pulley belt-shifter, ready to change the belt from one step to another.

Fig. 1. Swinging Arm on Lathe.*

Fig. 2. Guard for Lathe Dog. (Boston Elevated Railway Company.)

Fig. 3. Safety Dogs. (Patented.)

Fig. 1 shows a device for handling lathe chucks or face plates. Men may be strained or otherwise injured in moving heavy parts of this kind by hand. Note belt-shifter under man's arm.

Figs. 2 to 5 illustrate various devices to prevent danger of persons being caught on the projecting screw used in the ordinary lathe dog. The "Iron Age" for February 15, 1912, gives an analysis of 670 lathe accidents, of which 71, or more than 10% of the total, were caused by the driving dog catching arms or clothing of workmen.

The use of a numbered rack, as shown in Fig. 4, prevents confusion in handling the different sized dogs. Socket wrenches, as illustrated in this picture, or open-end wrenches, are required for these dogs.

Fig. 4. Lathe Dog Rack.*

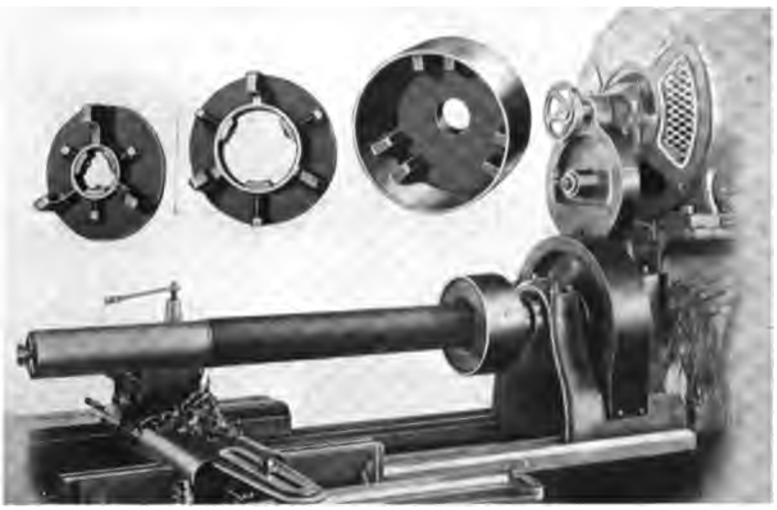


Fig. 5. Safety Lathe Dog. (Patented.)

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

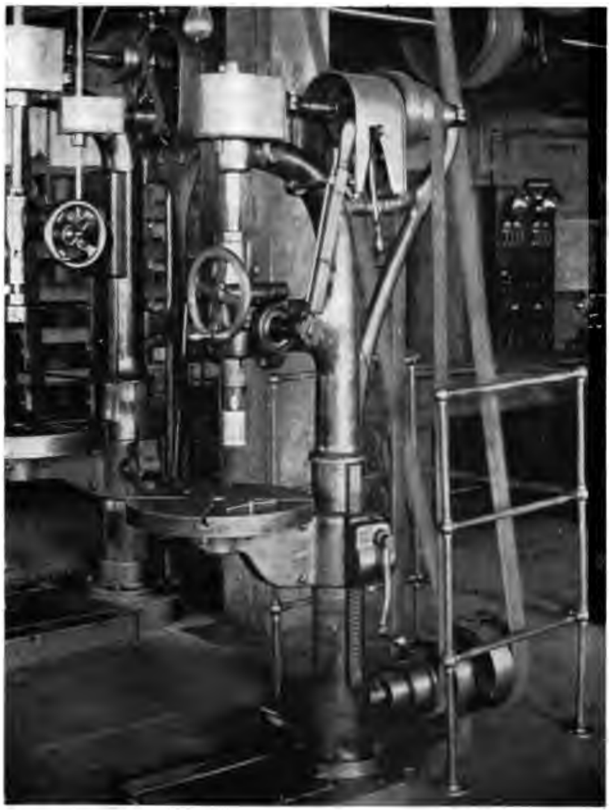


Fig. 1. (Courtesy of United States Envelope Company.)

Fig. 2. (Courtesy of American Steel and Wire Company.)

Fig. 1 shows a good arrangement of belt and gear guards for an upright drill. (See also Fig. 4, P. 162.)

Fig. 2 illustrates a radial drill equipped with various types of safeguards, including complete enclosure of all gearing as well as guard for the counterweight. The latter consists of a plate securely bracketed to frame of machine, with sides enclosed in woven-wire fabric so as to avoid danger of fingers being caught between counterweight and bottom plate.

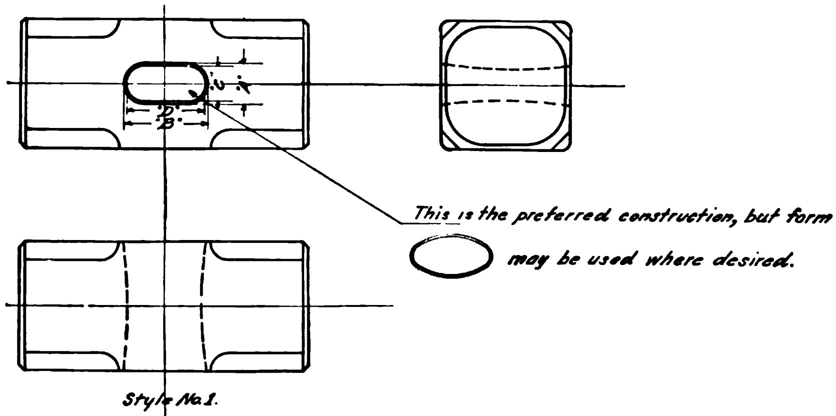
Fig. 3 shows the results of a workman having his clothing caught on the projecting set screw of a drill chuck. Only countersunk screws should be used for such service.

The belts on multiple drills are generally arranged at such a height that if one should break it might injure the eyes of operator. In Fig. 4 a good type of guard for preventing such accidents is illustrated. The vertical spindles are also guarded and a belt-shifter is provided.

* Courtesy of General Electric Company.

Fig. 3. (Courtesy of Avery Company.)

Fig. 4.*



Weight of Hammer	A.	B.	C.	D
3#, 4#	9/16"	1 1/8"	1/2"	1 1/16"
5#, 6#	5/8"	1 1/4"	9/16"	1 3/16"
8#, 10#	3/4"	1 1/2"	5/8"	1 3/8"
12#, 16#	7/8"	1 5/8"	3/4"	1 1/2"

Hammers in this list to be made as per Style No. 1.

Weight of Hammer	A.	B.	C.	D	E.	F.
20#	1"	1 5/8"	7/8"	1 1/2"	4"	3 1/2"
30#					4 1/4"	3 3/4"
40#	1 1/8"	2"	7/8"	1 1/2"	4 3/4"	4"
50#					5 1/4"	4 1/2"

Hammers in this list to be made as per Style No. 2.

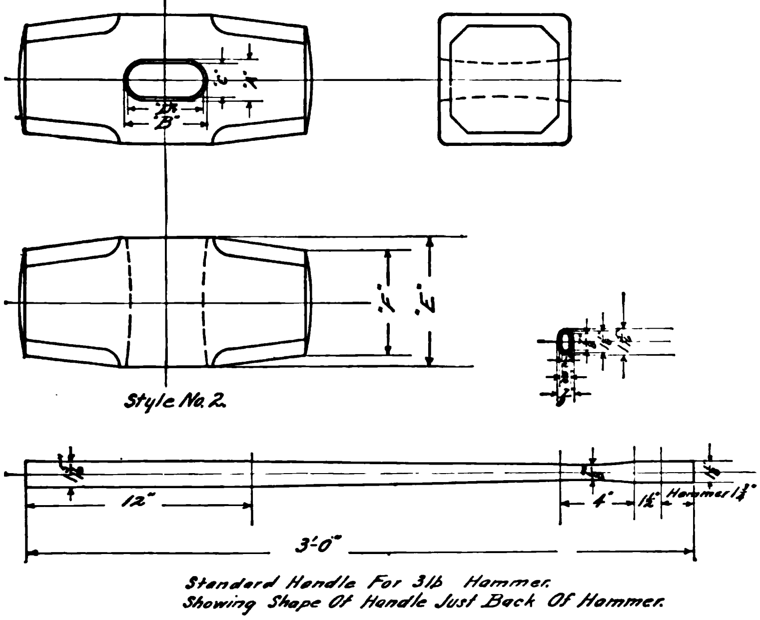


Fig. 1. Standard Hammer Heads and Handles.*

Fig. 2. Fastening for Hammer Handle. (Patented.)

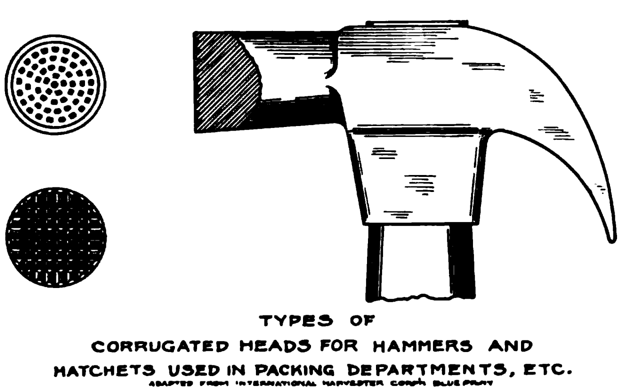


Fig. 3. Safety Hammer Heads, to Prevent Nails Flying when Struck by Hammer.

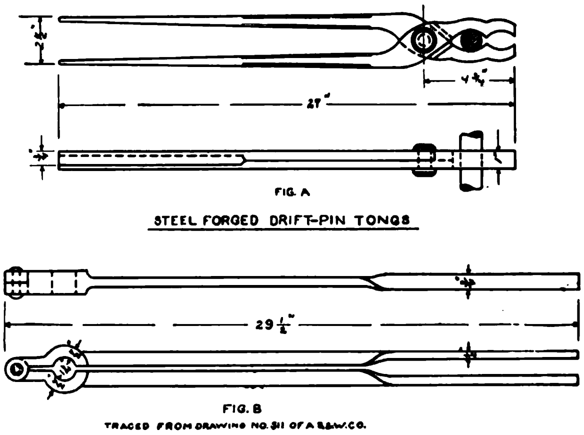


Fig. 4. Safety Tongs for Holding Drift-Pins. (American Steel and Wire Company.)

*** Adapted from drawing of Illinois Steel Company, subsidiary of United States Steel Corporation.**

CHAPTER 22

CARPENTER SHOP AND WOODWORKING EQUIPMENT

IN purchasing new woodworking machinery, it is recommended that specifications, as mentioned in connection with machine tools, Chapter 21, be used.

The woodworking industry furnishes a difficult problem from the standpoint of applying satisfactory guards to dangerous machines. This is especially true as regards circular saws.

SAW-GUARDS

Many saw-guards have been developed by machinery manufacturers for sale, and by private companies for their own use, but it is practically impossible to design an effective guard which can be used on all kinds of work.

Where long material of medium thickness is being split or "ripped," it is a simple matter to provide a hood which will ride over the piece and give a good degree of protection. Where thick or irregular-shaped pieces are being handled however, as in pattern work, it is often impossible to use any type of guard. Where thin edgings are being taken off, the guide must be brought up close to the saw blade, leaving insufficient clearance for a guard between the saw and guide.

It thus follows that the best that can be expected is a saw-guard which may be used on certain kinds of work, but which must be put out of the way when other work is being done. This means that constant attention is required to insure the use of the guard for even the service to which it is adapted.

Any one who has had experience in such matters will realize the difficulty of getting workmen to constantly replace a guard which must be frequently removed, and this feature largely accounts for the opposition which woodworkers offer almost universally to any form of saw-guard. This does not mean, however, that a guard is of no value, since it makes a definite reduction in the aggregate accident hazard if it is kept in place part of the time only.

It is accordingly desirable to furnish a guard for every circular saw, of the best type available, and to make every possible effort to see that it is used as much of the time as practicable. If the saw is doing one kind of work only, it may be possible to use the guard all of the time.

In order to give satisfactory results, a circular saw-guard should comply as fully as possible with the following conditions: —

1. It should adjust itself automatically to different thicknesses of material, within a range of, say three inches.
2. It should permit a view of the saw blade while it is in use.
3. It should be rigidly supported so as to minimize vibration and any danger of the guard being brought in contact with the saw blade.
4. The hood should preferably be made of some soft metal such as aluminum or brass, so that if it should accidentally strike the saw the latter will not be broken.
5. The guard supports should be arranged in such a manner as will not interfere with the action of the workmen in pushing pieces of wood through.
6. The guard should be permanently attached so that it is difficult to entirely remove it, but should be so arranged that it can be swung out of the way quickly, when work is being done to which it is not adapted, and as quickly returned to place.

The guard shown in Fig. 1, P. 213, meets these requirements. (See also P. 215.)

The following list gives an analysis of 103 consecutive accidents reported to an insurance company in the course of about one year, from circular saws: —

Fig. 1. Guarded Circular Saw.*

Fig. 2. Saw with Mechanical Feed.*

A good guard for circular saws is shown in Fig. 1. The hood is made of brass and is counterbalanced by a spring. The guide slides back and forth by means of a handle. This handle controls a finger projecting through the guide, to be used in pushing narrow pieces past the saw. Note also spreader back of saw blade.

Saws with mechanical feed are safer than ordinary hand-fed circular saws. In Fig. 2 the feed roll is protected, and an additional guard is placed over the saw to deflect knots or other pieces which might fly towards the operator.

Fig. 3. Saw-Guard for Special Work. (Eastman Kodak Company.)

Fig. 4. Guarded Tenoning Machine. (Norton Company.)

Fig. 3 shows a good arrangement to prevent small pieces from "kicking back," the wooden combs permitting movement in one direction only; these combs also serve to guard the saw blade.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

1. *Struck by stock kicking back*		25
2. *Cut by saw:*		
While sawing stock	45	
Brushing off chips, etc.	8	
Stock "kicking" forced hand on saw	9	
Saw "jumping" (through soft spot, etc.,	3	
Reaching (clothing caught, 1; direct contact, 3)	4	
Slipped and fell on saw	1	
Adjusting screw securing stock	1	
Walking by saw	1	
Hand slipped while dressing belts	1	
Oiling	1	
Picking up stock	1	
Misc.	3	78
Total		103

As will be apparent from this list, a large percentage of all saw accidents are caused by material jamming between the saw blade and the guide, or being caught in some other manner by the saw, and thrown back towards the operator; this frequently results in serious injuries.

A "spreader" or riving-knife back of the saw blade (see Fig. 1, P. 213) is of much value in properly guiding the pieces through and preventing accidents of this kind. This cannot be used, however, for rabbeting or other work where a groove is being cut in the bottom of the piece, unless the knife is adjustable so that its upper end does not project above the saw blade.

Accidents are often caused by an operator trying to cut pieces of wood on a circular saw which are too small to permit of their being held securely by hand. It is sometimes possible to provide a holder with handles or other means for gripping it, in which the small piece may be placed and cut safely. Small work of this kind can usually be handled more advantageously on a band saw.

A notched stick or other suitable device should be furnished for pushing narrow pieces past the saw blade.

Saws with automatic feed are much safer than the ordinary hand-fed type, and their use is recommended wherever practicable. (See Fig. 2, P. 213). They cannot be used advantageously for short or very thick pieces, however, so that at best they take care of only the least hazardous type of work.

SWING SAWS should have the upper portion of the blade covered. They should also be equipped with a chain or other means for retaining the counterweight in case it should fall, and a positive stop to limit the swing of the saw. (See Fig. 5, P. 216.)

"RAILROAD" SAWS should have a guard over the treadle to prevent any possibility of its being stepped on accidentally and thus bringing the saw forward unexpectedly. The saw should also be provided with a hood or guard.

BAND SAWS can be more readily protected than those of circular type. It is practicable to completely enclose the upper and lower wheel and all portions of the saw blade except that between the guide and the table, thus minimizing danger of contact with moving parts. (See Page 216.)

WOOD JOINTERS or buzz planers can also be protected so as to practically eliminate danger of accidents. Machines of this type, unless automatically fed, should be equipped with a circular head of safety type. (See Page 218.) Repeated experience has shown that a head of this kind inflicts only a slight injury in case a hand is accidentally thrown against it, taking off thin slices of flesh where the old type of square head would remove entire fingers. (See Fig. 5, P. 218.)

In addition to the circular head, a guard should be installed over the knives, arranged so that it swings away from the guide when a piece is pushed through but covers that portion of the outer end of the knives which is not in actual use. To be of much value, a guard of this type should be entirely automatic in action, since workmen cannot be depended upon to adjust such guards to varying widths and thicknesses of work. (See Fig. 1, P. 217.)

A planer protected in this manner offers but little accident hazard, although there is still the possibility of a piece "jumping" or splitting, and thus bringing the operator's hand into contact with the knife at the point where the work is passing, and which is consequently not

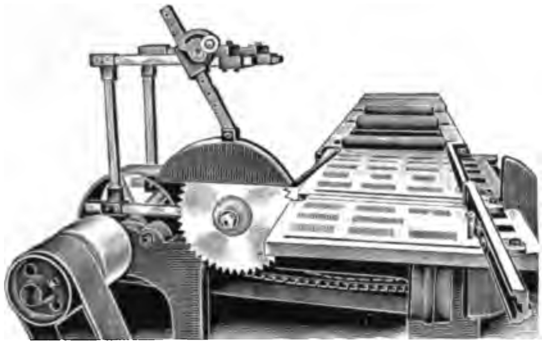


Fig. 1. Guard for "Railway" Cut-Off Saw.

Fig. 2. Saw-Guard supported from Floor.

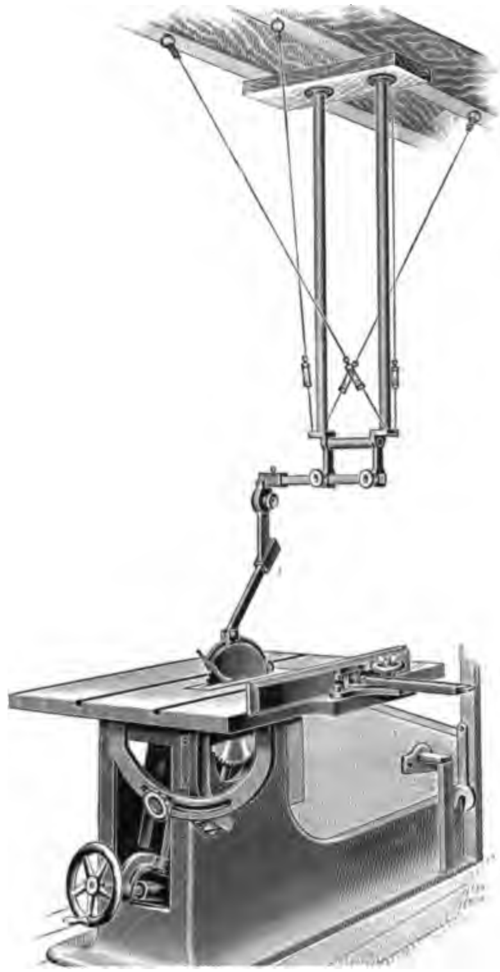


Fig. 3. Saw-Guard supported from Ceiling.

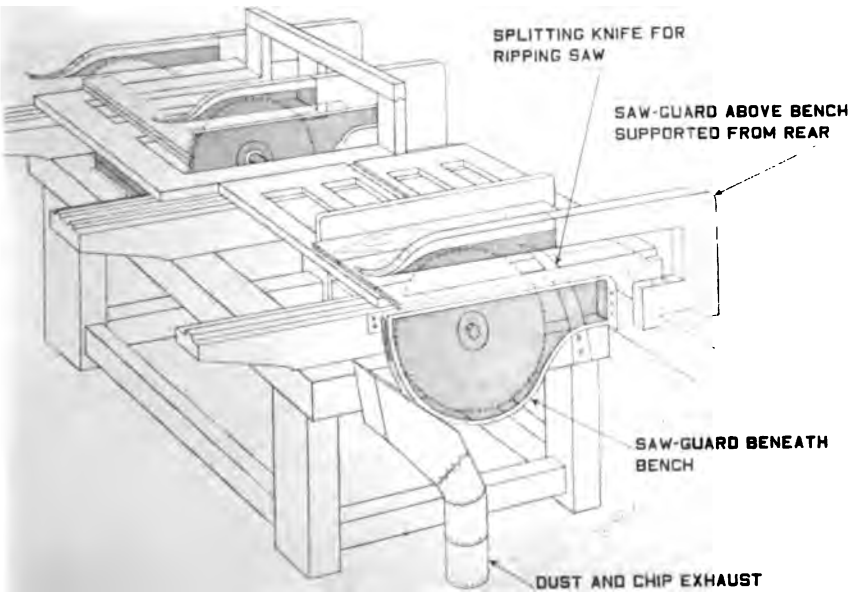


Fig. 4. Box-Making Saws with Guards supported from Framework of Machine.*

The illustrations on this page show various types of saw-guards, Nos. 1, 2, and 3 representing manufactured articles.

No. 4 is a guard installed by a private concern for its own use.

It is practicable to use some form of saw-guard a large percentage of the time, thus reducing the total hazard materially.

Note spreaders in Figs. 2 and 4, and exhaust connection in Fig. 4.

* Courtesy of
Remington Typewriter Works.

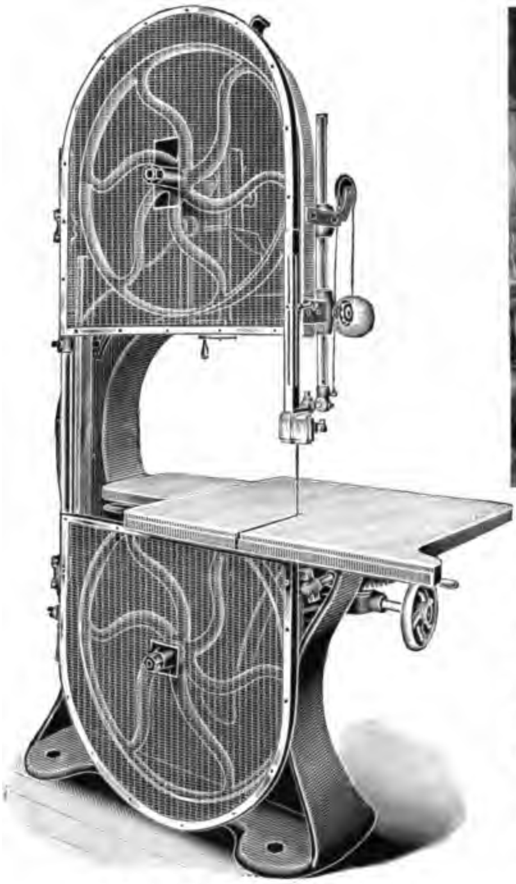


Fig. 1. Band Saw-Guard.

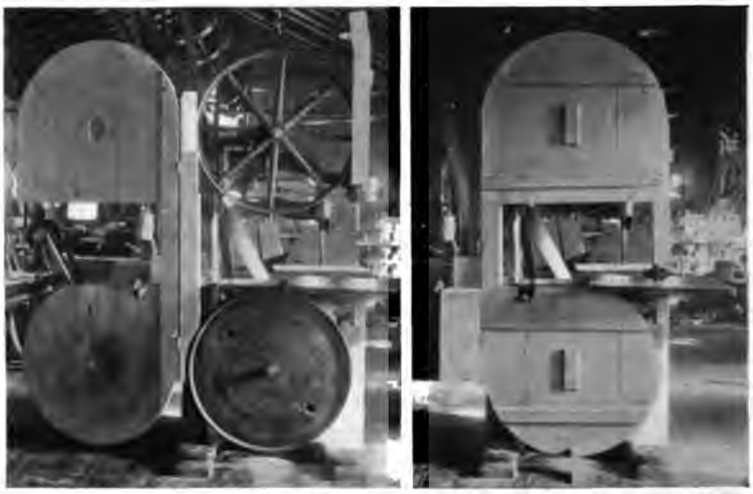


Fig. 2. Wooden Guards for Band Saw. Fig. 3.*

Figs. 1 to 3 illustrate model safety installations for band saws. All portions of the saw blade are guarded, except that which is actually used in sawing. The strip just above the guide prevents a breaking saw from springing outward, and also obviates danger of a man's head coming in contact with the saw blade.

Fig. 4 shows a guard for the boring bit of an auger. This protects the revolving bit in its upper position, but offers no interference with the free movement of the bit when in use.

Fig. 4. Auger-Guard.

Fig. 5 illustrates a well-protected swing saw; the belt is guarded, and a hood with convenient handle is provided. The counterweight is secured in position by two set screws, and a pin through the end of the counterweight lever prevents danger of its slipping off. Sometimes these saws are provided with chains to limit their travel. In the case illustrated, however, the construction of the guard is such as to minimize danger of any one being cut if the saw should swing beyond the table.

Fig. 5. Guarded Swing Saw.

* Courtesy of Tennessee Iron and Railroad Company, subsidiary of United States Steel Corporation.

Fig. 1. Jointer Guards.*

Fig. 2. Protected Sticker. (Eastman Kodak Company.)

The surface planer shown in Fig. 3 is equipped with mechanical feed. This type of machine is inherently safer than the hand-fed machine illustrated in Fig. 1.

Fig. 3. Guarded Surface Planer.*

Where the latter type is used, it should be equipped with a safety cylinder (see Page 218), and with an effective guard over the knives. That shown in Fig. 1 gives good protection, its operation being entirely automatic. The portion of the knife back of the guide is also provided with a guard, which curls up automatically as the guide is pushed towards the rear of the table.

Attention is directed to the belt-guards in Figs. 1 and 3, also to the enclosure of cross-shaft back of the planer near the floor in Fig. 3.

Fig. 2 shows a Sticker with guarded feed roll, and exhaust connection. The latter should be applied to planers and other dust-producing machines.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

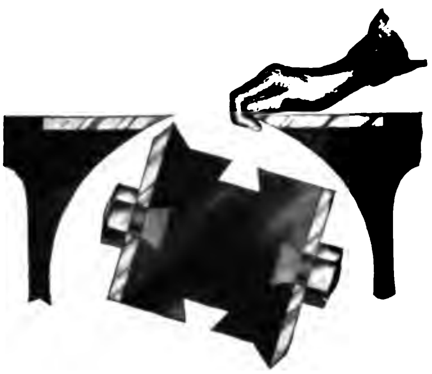


Fig. 1. " Square " Jointer Head.

Fig. 2. " Circular " Jointer Head.

Figs. 1 and 2 illustrate the superior safety features of the circular jointer head as compared with the old type of square head. The tendency of the circular head seems to be to throw the hand outward, thus minimizing the injury, whereas that of the square head is just the reverse.

Fig. 3 shows a standard make circular jointer head, of which there are several on the market.

Fig. 5 shows a workman whose hand came in contact with a safety jointer cylinder. A small white scar (indicated by arrow) on one finger is the only permanent result of this accident. Had a square head been in use, the entire hand would probably have been lost.

Fig. 3. Type of Circular Jointer Head.

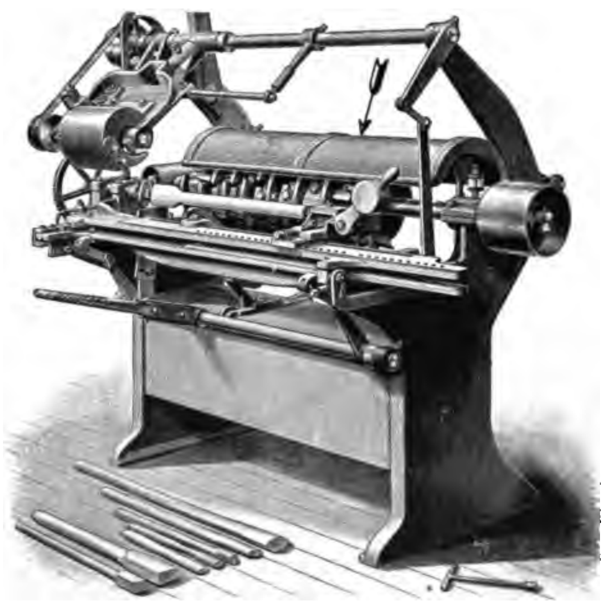


Fig. 4. Handle Lathe with Guard over Cutting Head.

Fig. 5. Man injured on Safety Jointer Cylinder.

Fig. 1.

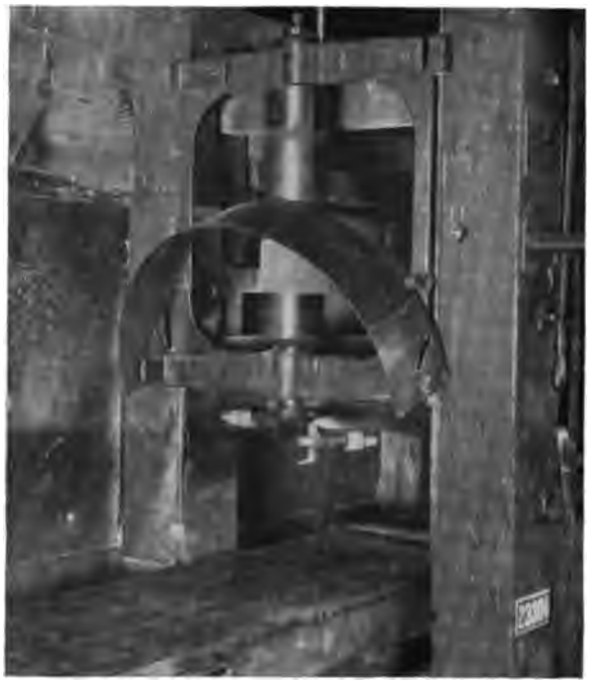


Fig. 2.

Guard for "Daniels" Planer. (American Steel and Wire Company.)

Figs. 1 and 2 show a good guard for "Daniels" planers. This guard prevents danger of any one falling against the revolving knives, and it will also stop a knife if it should fly out of the holder. The guard is conveniently arranged, and does not interfere with the movements of the operator.

Fig. 3. Shaper Guard. (Eastman Kodak Company.)

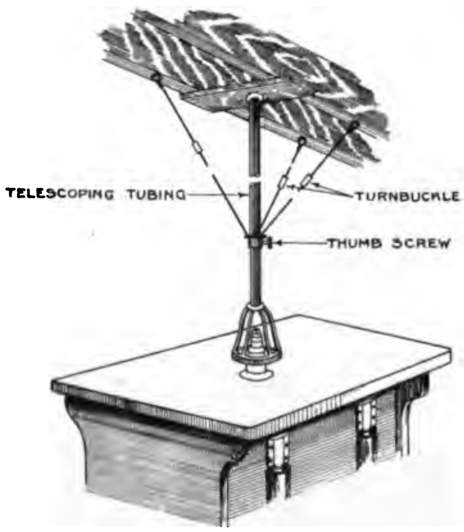


Fig. 4. Shaper Guard.

Figs. 3 and 4 show guards for shapers or irregular moulders. These guards can be raised or lowered by means of the hand wheels (Fig. 3) and thumb screw (Fig. 4).

guarded; if the safety cylinder is used, however, such an accident is usually not serious.

Where long pieces only are handled, a machine with automatic feed can be used, in which case the danger is greatly reduced. (See Fig. 3, P. 217.) It is well to provide a bar or other suitable guard in front of the feed roll of these machines, to prevent fingers being caught between the roll and the entering piece.

It is dangerous to plane small pieces by hand; where such work must be done, a holder, as mentioned above for circular saws, should be provided.

WOOD SHAPERS are similar to circular saws as regards the difficulty of applying an effective guard. It is possible to provide a guard which reduces the hazard, but this must be arranged so that it can be thrown out of the way at times. It should be supported from the ceiling rather than from the table of the machine, in order to permit the free handling of work on the table. (See Figs. 3 and 4, P. 219.)

MISCELLANEOUS WOODWORKING MACHINES, Matchers, Stickers, Tenoning Machines, Handle Lathes, Sanders, etc., should have cutting members, feed rolls and other moving parts which might cause injury, guarded as completely as the character of the work will permit. (See Fig. 5, P. 67, Figs. 1 and 2, P. 217, Fig. 4, P. 213, Fig. 2, P. 213, etc.)

EXHAUST SYSTEMS

It is desirable to equip all woodworking machines throwing off dust or fine chips with effective exhaust systems. (See Fig. 5, P. 67, and Fig. 2, P. 217.) In many cases the exhaust hood can be utilized to advantage for the protection of cutting parts.

CHAPTER 23

ABRASIVE WHEELS

A COMMITTEE appointed by the Abrasive Wheel Manufacturers to draft a "Safety Code for the Use and Care of Abrasive Wheels and the Parts of Grinding Machines Related Thereto," completed its report in 1915. This report, which is reprinted below, was approved by some twenty of the leading abrasive wheel manufacturers of this country.* It represents an excellent practical standard, and is recommended for adoption by all those who are interested in the safe operation of emery or abrasive wheels.

In this connection the following points are worthy of special emphasis, on account of their importance in avoiding accidents from abrasive wheels: —

1. **Flanges.** It should be borne in mind that the power required to turn a grinding wheel is transmitted through the pressure of the flanges on the sides of the wheel; hence these flanges should be large enough to distribute the stresses over the surface of the wheel, and not concentrate them at the centre, as results from the use of small flanges.

For new equipment, the standard flange diameters given below in tables A–9 and D–12, are recommended. Where flanges on equipment already in use are less than one-third the wheel diameter, it is desirable to change them to conform to these standaıds. Inside flanges should be pressed or keyed in place; they should never be loose.

2. **Cushion Washers.** The ordinary abrasive wheel is brittle, like glass. Unless cushion washers of blotting-paper, rubber, leather or other suitable material are used, a slight inequality in the wheel or washer may produce stresses, when pressure is applied through the nut, which will cause the wheel to break or "explode" where otherwise it would be perfectly safe.

When these two simple precautions are observed, — that is, the use of flanges of adequate size, with cushion washers underneath, — the danger of accident has been largely reduced. Numerous cases are on record where wheels have broken in service and the standard mounting mentioned above has held the pieces together so that none of the parts flew out, even though the wheels were not of safety shape. (See Fig. 2, P. 222.)

3. **Tool Rest Adjustment.** A relatively frequent cause of emery-wheel accidents is the ***jamming of tools between the wheel and rest,*** where the latter is not kept close to the face of the wheel. Great care should be taken, accordingly, to keep the rest closely adjusted as the wheel wears down.

4. **Hoods** are required by law in many States for emery wheels or belts, buffing wheels, etc., in connection with a suitable exhaust system to carry away the dust. (See Pages 222 and 226.) These requirements are usually framed for health conservation, but in complying with them the employees can also

* This includes the following companies: — Abrasive Material Co., Philadelphia, Pa.; American Emery Wheel Works, Providence, R. I.; Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.; Carborundum Company, Niagara Falls, N.Y.; Canadian-Hart Wheels, Ltd., Hamilton, Ont., Canada; Commercial Corundum & Emery Wheel Co., Chicago, Ill.; Cortland Corundum Wheel Co., Cortland, N.Y.; Dayton Grinding Wheel Co., Dayton, Ohio; Detroit Grinding Wheel Co., Detroit, Mich.; Dominion Abrasive Wheel Co., Toronto, Canada; Hampden Corundum Wheel Co., Springfield, Mass.; Manhattan Rubber Manufacturing Co., New York City; National Corundum Wheel Co., Buffalo, N.Y.; New York Belting and Packing Co., New York City; Norton Company, Worcester, Mass.; Pittsburgh Emery Wheel Co., Pittsburgh, Pa.; Safety Emery Wheel Co., Springfield, Ohio; Springfield Mfg. Co., Bridgeport, Conn.; Star Corundum Wheel Co., Detroit, Mich.; Sterling Grinding Wheel Co., Tiffin, Ohio; Superior Corundum Wheel Co., Waltham, Mass.; Vitrified Wheel Co., Westfield, Mass.; Waltham Emery Wheel Co., Waltham, Mass.

Fig. 1. Hoods, Belt Guard, Plate-Glass Eye Shields, etc., for Emery Wheels.*

Fig. 2. Wheels of "Safety Shape."

These wheels have protective flanges, which are often effective in retaining parts of a broken wheel. While they cannot be considered an absolute safeguard (see Fig. 2, Page 226), such flanges afford considerable protection and are recommended where the character of the work will not permit the use of an enclosing hood.

Fig. 3. Model Installation of Nail Die Grinders.*

Note protection hoods, plate-glass eye shields, exhaust system and arrangement of shaded electric lights.

Fig. 4. Protection Hood used on Grinding Machine.

This is equipped with an exhaust connection to carry away dust.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

be protected from bursting wheels if the hoods are suitably constructed (for hood arrangements see Pages 222 and 226).

Where the work handled is such that a hood giving thorough enclosure of the wheel is impracticable, wheels of safety shape should be used. In such cases the wheel should never project from the flanges more than the distance permitted by table A–9. Two or more sets of flanges should be kept on hand, so that smaller ones can be put on as the wheel wears down, as mentioned in rule A–2.

5. **The driving belt and pulley** of each abrasive wheel or grinder should be guarded, in accordance with the general standards outlined in Chapter 15. (See Fig. 1, P. 222.)

6. **The use of large-sized spindles** of a uniform diameter for all wheels in a given plant (say 2″ diameter for wheels from 8″ to 24″ diameter) is recommended. This reduces the danger from bent spindles, and makes it a much simpler matter to keep the wheels running true. Where a single spindle diameter is adopted for an entire plant, all wheels are interchangeable, and they can be moved from larger to smaller stands as they wear down.

THE "SAFETY CODE" mentioned above is as follows:

"Abrasive Wheel Manufacturers recommend three general types of safety devices to be used for grinding wheels, namely: protection flanges, protection hoods and protection chucks.

Protection Flanges

A 1 — The Abrasive Wheel Manufacturers recommend protection flanges of the double or single concave type, used in conjunction with wheels having double or single convex tapered sides or side. (See Fig. 2, P. 222.)

A 2 — Flanges of the sizes shown opposite wheel diameters in column C, Article A 9, shall be used. As wheels wear, size of flanges, as indicated in column C, article A 9, shall be maintained.

A 3 — New installations of protection flanges for double tapered wheels shall have a taper of not less than three-quarters (¾) of an inch to the foot for each flange, and the center of flange shall conform with the dimensions shown in column B, article A 9. Such flanges shall be of a thickness not less than is shown in column D, article A 9.

A 4 — New installations of protection flanges for single tapered wheels shall have a taper of not less than three-quarters (¾) of an inch to the foot, and the center of flange shall conform with dimensions shown in column B, article A 9. Thickness of such flanges shall be as shown in column F, article A 9.

A 5 — Each flange, whether straight or tapered, shall be relieved or recessed at the center at least one-sixteenth (1/16) of an inch on the side next to the wheel for a distance as specified in column E, article A 9.

A 6 — All tapered flanges over ten (10″) inches in diameter shall be of steel, or other material of equal strength. Tapered flanges ten (10″) inches and smaller in diameter may be made of cast iron.

A 7 — All flanges shall be accurately turned, correct to dimensions and in balance, except flanges which are purposely made out of balance. Two such flanges are known as balancing flanges and are sometimes used to counteract out of balance condition in an abrasive wheel.

A 8 — Both flanges in contact with the wheels shall be of the same diameter. (See Figs. 2 and 3, P. 224.)

A 9 —

DIMENSIONS OF TAPERED FLANGES AND TAPERED WHEELS WHERE HOODS ARE NOT USED IN CONJUNCTION THEREWITH

A — Maximum flat spot at center of flange.
B — Flat spot at center of wheel.
C — Minimum diameter of flange.
D — Minimum thickness of flange at bore.
E — Minimum diameter of recess in taper flanges.
F — Minimum thickness of each flange for single taper at bore.

Diameter of Wheel in Inches	A	B	C	D	E	F
6	0	1	3	3/8	2	3/8
8	0	1	5	3/8	3½	3/8
10	0	2	6	½	4	½
12	4	4½	6	5/8	4	5/8
14	4	4½	8	5/8	5½	¾
16	4	6	10	5/8	7	7/8
18	4	6	12	¾	8	1
20	4	6	14	¾	9	1
22	4	6	16	¾	10½	1 1/8
24	4	6	18	¾	12	1 1/8
26	4	6	20	¾	13½	1 1/8
28	4	6	22	7/8	14½	1¼
30	4	6	24	7/8	16	1¼

NOTE: Where hoods are used in conjunction with tapered wheels and tapered flanges the specifications given in article D 12 may be followed.

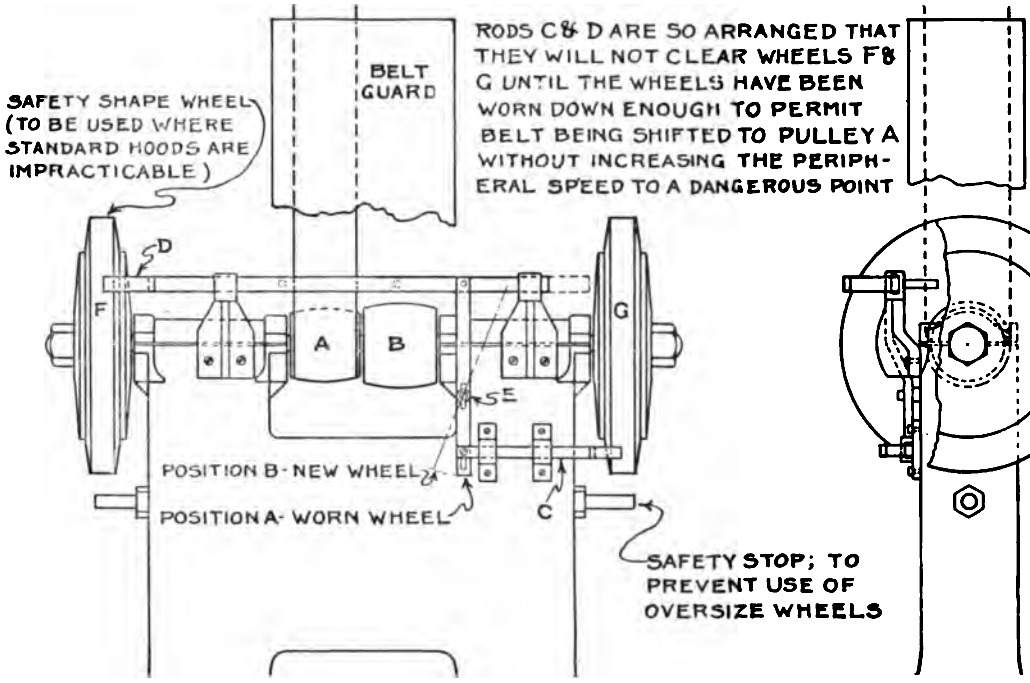
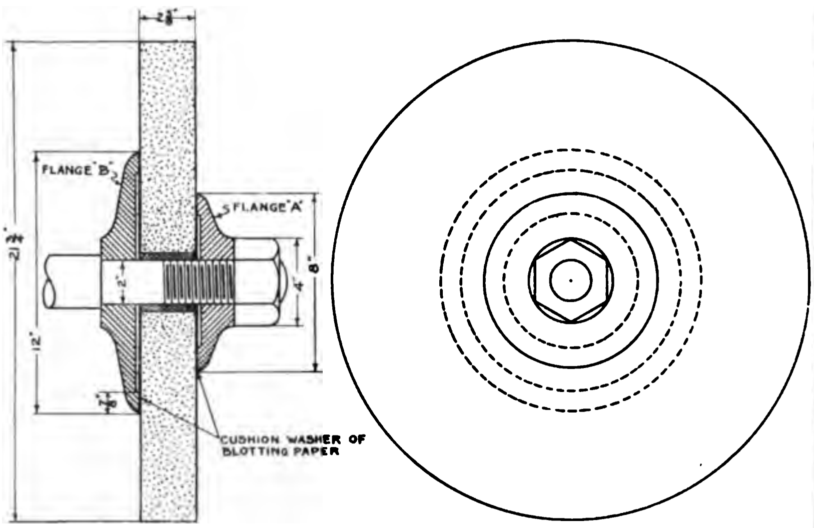


Fig. 1. Limiting Devices for Emery Wheels.*

A dangerous surface speed may be caused by the use of over-size wheels, or by failure to shift the belt from the small to the large pulley when a new wheel is installed. Fig. 1 shows safeguards for both of these conditions.



ORIGINAL DIAMETER - 24"
AT TIME OF ACCIDENT { R.P.M. - 1125
PERIPHERAL VELOCITY - 6406.04 FT. PER MIN.

Fig. 2.

Fig. 3.

Fig. 3 shows a grinder just after the wheel burst and fatally injured the operator. The wheel had unequal flanges (see Fig. 2), and was running at over-speed on account of belt having been left on wrong step of cone pulley when wheel was changed. The use of unequal flanges should never be permitted.

* From "Safety as Applied to Grinding Wheels." (Norton Company.)

Protection Hoods

B 1 — Protection Hoods shall always be used when practicable with wheels not provided with protection flanges. Hoods shall be designed and constructed of a material sufficiently strong to retain all pieces of a broken grinding wheel. (See Pages 222 and 226.)

B 2 — Hoods shall conform as nearly as possible to the periphery of the wheel, and shall be so designed as to leave exposed the least portion of the wheel compatible with the work, and shall be of the adjustable type or provided with a sliding tongue or similar device, or a method of contracting the rim, for the purpose of closing the opening in the hood as the wheel is reduced in diameter, to afford maximum protection at all times. (See Fig. 3, P. 226.)

B 3 — Protection hoods must be securely fastened to the grinding machine or floor.

B 4 — Protruding ends of the wheel arbors and their nuts shall be guarded. (See Fig. 4, P. 65.)

Cups, Cylinders, and Sectional Ring Wheels

C 1 — Cups, Cylinders and sectional ring wheel shall be either protected with hoods, or enclosed in protection chucks, or surrounded with protection bands. Not more than one-quarter (¼) of the height of such grinding wheels shall protrude beyond the provided protection.

General Safety Requirements

D 1 — Competent men shall be assigned to the mounting, care and inspection of grinding wheels and machines.

D 2 — Before mounting, all wheels shall be closely inspected to make sure that they have not been injured in transit, storage or otherwise. For added precaution, wheels other than of the elastic and vulcanite type should be tapped lightly with a hammer; if they do not ring with a clear tone they should not be used. Damp wheels when tapped with a hammer may not give a clear tone. Wheels must be dry and free from sawdust when applying this test.

D 3 — Grinding wheels shall fit freely on the spindles; they shall not be forced on, nor shall they be too loose.

D 4 — Wheel arbor holes shall be made .005″ larger than the machine arbor.

D 5 — The soft metal bushing shall not extend beyond the sides of the wheel at the center.

D 6 —

MINIMUM SIZES OF MACHINE SPINDLES IN INCHES FOR VARIOUS DIAMETERS AND THICKNESSES OF GRINDING WHEELS

Diameter in Inches	*Thickness of Wheel in Inches*																		
	¼	⅜	½	⅝	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	4	4½	5
6	½	½	½	½	½	½	⅝	⅝	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1
7	½	¾	½	½	⅝	⅝	⅝	¾	¾	¾	¾	¾	¾	1	1	1	1	1	1
8	⅝	½	⅝	⅝	⅝	⅝	¾	¾	¾	1	1	1	1	1	1	1	1¼	1¼	1¼
9	⅝	⅝	⅝	⅝	¾	¾	¾	¾	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼
10	¾	⅝	¾	¾	¾	¾	¾	¾	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
12	¾	¾	¾	¾	¾	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1½	1½	1½
14	⅞	⅞	⅞	⅞	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½
16					1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1¾	1¾	1¾	1¾
18					1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1¾	1⅞	1⅞
20						1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1¾	1⅞	1⅞	1⅞	1⅞
24						1½	1½	1½	1¾	1¾	1¾	1¾	1¾	1¾	2	2	2	2	2
26							1½	1½	1¾	1¾	1¾	1¾	2	2	2	2	2¼	2¼	2¼
30								1¾	1¾	2	2	2	2	2	2¼	2¼	2½	2½	2½
36									2	2¼	2¾	2¼	2½	2½	2½	2¾	2¾	3	3

D 7 — Ends of spindles shall be threaded left and right, so that the nuts on both ends will tend to tighten as the spindles revolve. Care should be taken in setting up machines that the spindles are arranged to revolve in the proper direction, else the nuts on the ends will loosen. (See article D 16.)

D 8 — Wheel spindles shall be of sufficient length to permit of the nut being drawn up at least flush with the end of the spindle, thus providing a bearing for the entire length of nut.

D 9 — The surfaces of wheels in contact with straight or tapered flanges, the surfaces of the flanges in contact with the wheels and the wheel washers between the flanges

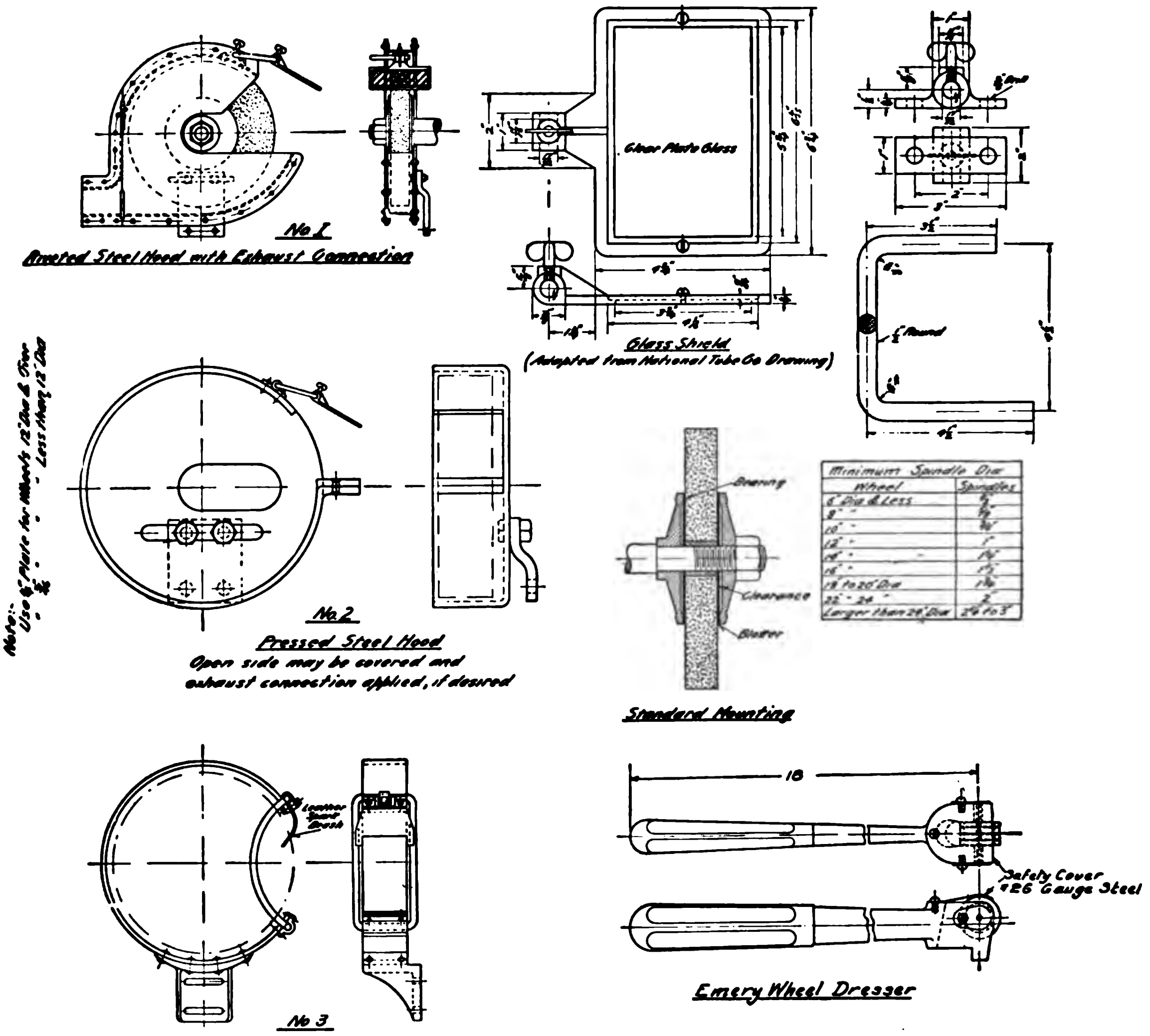


Fig. 1. Hoods, Plate-Glass Shield, Safety Wheel Dresser, etc.*

Fig. 2. Test of Tapered Flanges, showing that pieces may break and fly from portion of wheel outside flanges.

Fig. 3. Test of Hood showing its effectiveness in retaining parts of broken wheel.

*** Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.**

and wheels shall be clean, smooth and free from foreign material.

D 10 — Size of straight flanges for straight wheels shall not be less than shown by column B, section D 12.

D 11 — All straight flanges shall be relieved or recessed at the center at least one-sixteenth (1/16) of an inch on the inside surface of flange for a diameter as specified in column C, Article D 12.

D 12 —

STRAIGHT FLANGES AND STRAIGHT WHEELS USED WITH PROTECTION HOODS

A	B	C	D
Diameter of Wheel in Inches	*Minimum Outside Diameter of Flange*	*Minimum Diameter of Recess*	*Minimum Thickness of Flange at Bore*
6	2	1	3/8
8	3	2	3/8
10	3½	2¼	3/8
12	4	2¾	½
14	4½	3	½
16	5½	3½	½
18	6	4	5/8
20	7	4½	5/8
22	7½	5	5/8
24	8	5½	5/8
26	8½	6	5/8
28	10	7	¾
30	10	7	¾

D 13 — Wheels shall never be run without flanges.

D 14 — Both flanges in contact with the wheels shall be of the same diameter whether straight or tapered.

D 15 — Wheel washers of compressible material, such as blotting-paper, rubber or leather, not thicker than approximately 0.025," shall be fitted between the wheel and its flanges. It is recommended that the wheel washers be slightly larger than the diameter of the flanges used.

D 16 — When tightening clamping nuts, care shall be taken to tighten same only enough to hold the wheel firmly, otherwise the clamping strain is apt to crack the wheel.

D 17 — Flanges, whether straight or tapered, must be frequently inspected to guard against the use of flanges which have become bent or sprung out of true, or out of balance. If a tapered wheel has broken, the tapered flanges must be carefully inspected for truth before using with a new wheel. Clamping nuts shall also be inspected.

D 18 — The work rest must be kept adjusted close to the wheel to prevent the work from being caught. Work rests must be rigid and always securely clamped after each adjustment.

D 19 — (1) A speed of 5,000 peripheral feet per minute is recommended as the standard operating speed for vitrified and silicate straight wheels, tapered wheels and shapes other than those known as cup and cylinder wheels, which are used on bench, floor, swing frame and other machines for rough grinding. Speeds exceeding 5,000 feet may be used upon recommendation of the wheel manufacturer but in no case shall a speed of 6,500 peripheral feet per minute be exceeded. (2) A speed of 4,500 peripheral feet per minute is recommended as standard operating speed for vitrified and silicate wheels of the cup and cylinder shape, used on bench, floor, swing frame and other machines for rough grinding. Speeds exceeding 4,500 peripheral feet per minute may be used upon recommendation of the wheel manufacturer but in no case shall 5,500 peripheral feet per minute be exceeded.

D 20 — For elastic, vulcanite and wheels of other organic bonds, the recommendations of individual wheel manufacturers shall be followed.

D 21 — For precision grinding an operating speed of 6,500 peripheral feet per minute may be recommended. Speeds higher than 6,500 peripheral feet per minute can be used only upon recommendation of the wheel manufacturer.

D 22 — The following table (see next page) gives revolutions per minute for various sizes of wheels for the peripheral velocities at the head of each column.

D 23 — Machine spindle speeds shall be tested and determined correct for size of wheel to be operated before wheel is mounted, and shall never be changed as a wheel is reduced in diameter, except by men assigned for such duties.

D 24 — If a wheel spindle is driven by a variable speed motor, speed control of the motor shall be enclosed in a locked case, or some device shall be used which prevents motor from being run at too high speeds.

Revolutions per Minute for Various Sizes of Grinding Wheels to give Peripheral Speed in Feet per Minute as Indicated by the Following Table

Diameter of Wheel in Inches	4,000	4,500	5,000	5,500	6,000	6,500
1	15,279	17,200	19,099	21,000	22,918	24,850
2	7,639	8,590	9,549	10,500	11,459	12,420
3	5,093	5,725	6,366	7,000	7,639	8,270
4	3,820	4,295	4,775	5,250	5,730	6,205
5	3,056	3,440	3,820	4,200	4,584	4,970
6	2,546	2,865	3,183	3,500	3,820	4,140
7	2,183	2,455	2,728	3,000	3,274	3,550
8	1,910	2,150	2,387	2,635	2,865	3,100
10	1,528	1,720	1,910	2,100	2,292	2,485
12	1,273	1,453	1,592	1,750	1,910	2,070
14	1,091	1,228	1,364	1,500	1,637	1,773
16	955	1,075	1,194	1,314	1,432	1,552
18	849	957	1,061	1,167	1,273	1,380
20	764	860	955	1,050	1,146	1,241
22	694	782	868	952	1,042	1,128
24	637	716	796	876	955	1,035
26	586	661	733	809	879	955
28	546	614	683	749	819	887
30	509	573	637	700	764	827
32	477	537	596	657	716	776
34	449	506	561	618	674	730
36	424	477	531	534	637	689
38	402	453	503	553	603	653
40	382	430	478	525	573	621
42	364	409	455	500	546	591
44	347	391	434	477	521	564
46	332	374	415	456	498	539
48	318	358	397	438	477	517
50	306	344	383	420	459	497
52	294	331	369	404	441	487
54	283	318	354	389	425	459
56	273	307	341	366	410	443
58	264	296	330	354	396	428
60	255	277	319	350	383	414

D 25 — Grinding machines shall be sufficiently heavy and rigid to prevent vibration, and they should be securely mounted on substantial foundations.

D 26 — No user of wheels shall use on any given machine a wheel of larger diameter or greater thickness than specified by the machine builder.

D 27 — Wheels which wear out of round shall be trued by a man assigned to that duty. If wheels become out of balance through wear and cannot be balanced by truing or dressing, they should be removed from the machine.

D 28 — A wheel used in wet grinding shall not be allowed to stand partly immersed in the water. Water-soaked portion may throw the wheel dangerously out of balance.

D 29 — Wheel dressers should be equipped with rigid sheet metal or other guards over the tops of the cutters to protect operator from flying pieces of broken cutters. (See Fig. 1, P. 226.)

D 30 — Goggles shall be provided for use of grinding wheel operators where there is danger of eye injury. They should be readily accessible, or better, should be the individual property of the operator. Where this is not done, men should be urged to wash their faces immediately before and after using the goggles.

D 31 — The space about the machine shall be kept dry, clean and as free as possible from castings or other obstructions.

D 32 — Grinding rooms shall not only be well ventilated and well lighted, but kept warm and dry. Machines shall be attached to a dust-exhausting system. Besides protection to the workmen, the dust-exhausting system prevents wear and tear on machinery and belts. (See Pages 66 and 222.)

D 33 — Care shall be exercised in the storage of wheels. They shall be stored in dry places and should be well supported on edge in racks. Work shall not be forced against a cold wheel, but the work applied gradually, giving the wheel an opportunity to warm and thereby eliminate possible breakage. This applies to starting work in the morning in grinding rooms which are not heated in winter, and new wheels which have been stored in a cold place.

Precautionary Suggestions

E 1 — It is recommended that where possible, straight flanges of the dimensions shown in article D 12 be used in conjunction with protection flanges. This recommendation is made as an additional protection to give added strength to the safety flanges.

E 2 — Cone pulleys determining the speed of a wheel should never be used unless belt locking devices are provided. (See Fig. 1, P. 224.)

E 3 — The maximum size of wheel which should be used with given operating speeds should be indicated on each machine.

E 4 — Grinding machines should be provided with a stop or some method of fixing the maximum size of wheel which may be used, at the speed at which the wheel spindle is running. (Fig. 1, P. 224.)

E 5 — Boxes must be of proper length to provide an ample bearing surface, and prevent heating or rapid wear. It is important that the bearings be kept well lubricated and properly adjusted. Ring oiling devices are recommended, amply protected from dust and grit, and box caps should be adjusted for take-up.

E 6 — For protection against flying chips, etc., plate glass in metal frames can be placed just above the grinding spaces of the wheels. (See Fig. 1, P. 222, and Fig. 1, P. 226.)

E 7 — Where it is impracticable or undesirable to use a glass shield, a leather flap may be attached to the hood and adjusted so as to interrupt sparks and dust. (Fig. 1, P. 226.)"

SPECIFICATIONS

In ordering new grinding equipment it is strongly recommended that the purchaser use safety specifications, which may read somewhat as follows: —

"This equipment shall comply fully with the Safety Code of the Abrasive Wheel Manufacturers, as regards Protection Hoods and Flanges, B, and D–9 to D–14, inclusive (or 'Protection Flanges, A' where hoods are impracticable); wheel washers, D–15; Belt Locking Device, E–2 (where wheel has cone pulley); wheel-limiting stop, E–4; and any other provisions of the Code affecting the safe design and construction of abrasive wheels and their stands. If the equipment should not comply with these standards in any respect the purchaser reserves the right to withhold payment until the standards shall have been met satisfactorily."

CHAPTER 24

LADDERS AND SCAFFOLDING

Ladders are responsible for a considerable percentage of all industrial accidents. Six deaths and 821 other injuries from the use of ladders were reported in Massachusetts during one year. (See Chapter 3.) The hazard from this source may be largely reduced by carrying out the following precautions: —

Stairways should be provided in preference to ladders (except when the angle from the horizontal must be more than 50°), wherever possible, particularly where frequently used. (For Stairways, see Page 69.)

FIXED LADDERS

Where ladders are necessary, they should be fixed permanently in position rather than portable. Steel is superior to wood for constructing fixed ladders, since steel ladders are practically indestructible. The rungs of wooden ladders are liable to break without warning; they are also subject to wear and cracking or splitting, so that careful attention is required to keep them in good condition.

At least 7″ clearance should be allowed back of fixed ladders, and care should be taken to avoid any obstruction that will decrease this clearance and interfere with a proper foothold on the rungs of the ladder. Serious accidents have resulted from pipes or other objects being placed back of a ladder in such a position as to cause a foot to slip from the rung. At least 30″ clearance should be allowed in front of fixed ladders.

Steel ladder rungs should be not less than $\frac{7}{8}$″ in diameter, spaced approximately 12″ centres. They should be securely riveted through slotted holes in the side members, to prevent turning. The side members or "stringers" should be not less than 2″ x $\frac{1}{2}$″, spaced approximately 15″ apart, and supported at intervals of not more than 10 feet, so as to make them rigid.

The stringers of ladders leading to roofs or overhead platforms should be carried to a point at least 3′ 6″ above the level of such roof or platform (the rungs being omitted from this portion of stringers). The ends should be preferably bent over or "goose-necked" and rigidly attached to a support, so as to enable persons to pass from the ladder with entire safety. (See Fig. 2, Page 74.) A platform should be provided between ladder and roof, where there is a space of more than 24″ at the top of the ladder, across which persons using the ladder must step.

The practice of grasping the stringers, instead of the rungs, of a ladder, has been occasionally suggested, but is of doubtful value. It requires less effort to support the weight of the body on a horizontal bar than on a vertical one. In case the feet should slip from the rungs of a ladder, there would accordingly be less likelihood of the hands losing their grip on the rungs than on the stringers.

Safety Cage

Where fixed ladders are high (say 15′ or over) it is desirable to protect them by means of safety cages. The safety cage consists of a series of parallel bars arranged so as to enclose any one using the ladder, in a cage or tube. This cage should be approximately 27″ inside diameter. (See Fig. 1, Page 231.)

It is well to divide ladders which are very high (say 30′ or over) into sections of fifteen to twenty feet in length, offsetting each section and constructing a railed landing between sections. (See Fig. 1, P. 233.) This limits the distance a man could fall in case an accident should occur. The danger of such a fall in a

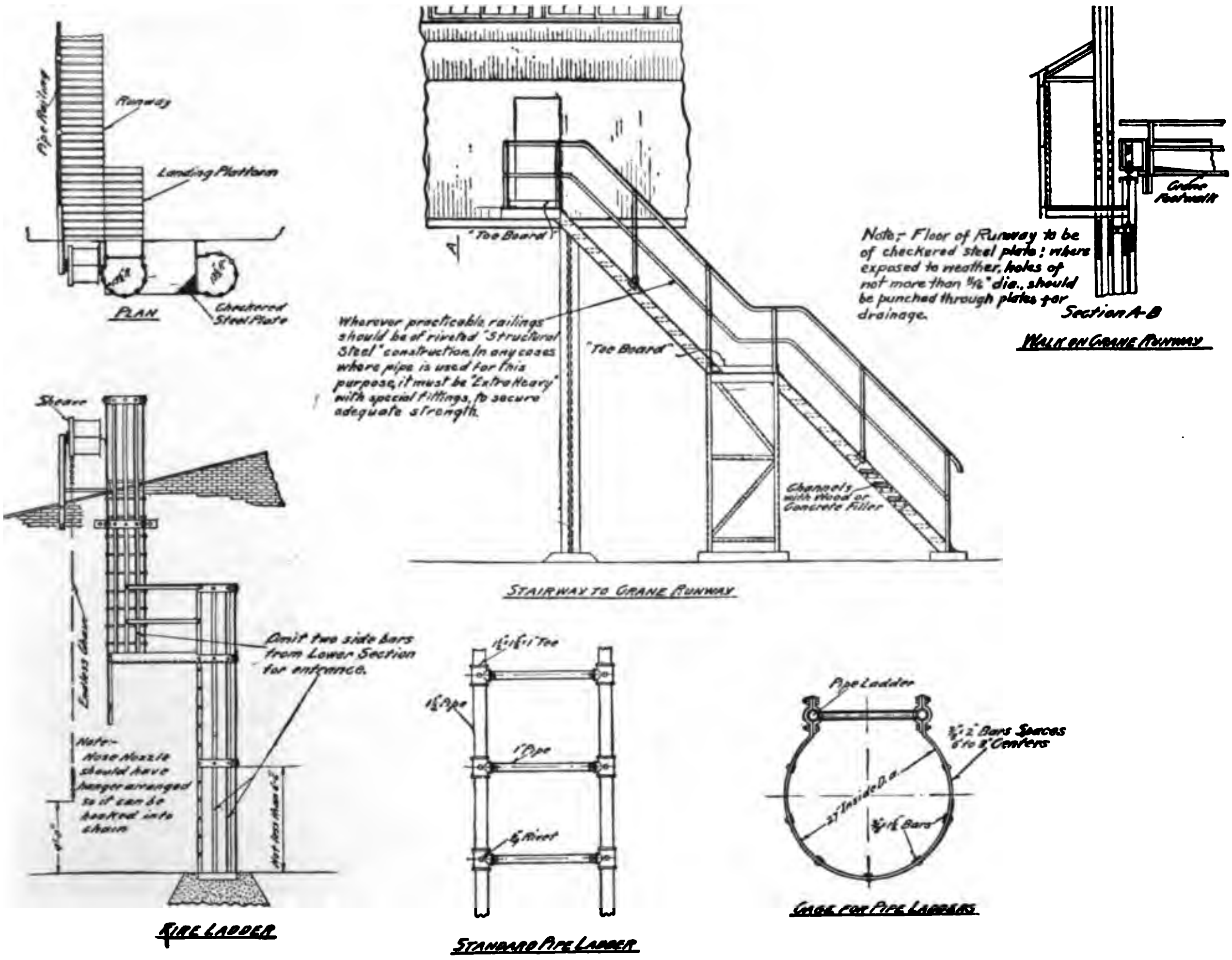


Fig. 1. Ladder Cage, Fixed Ladders, Walks, etc.*

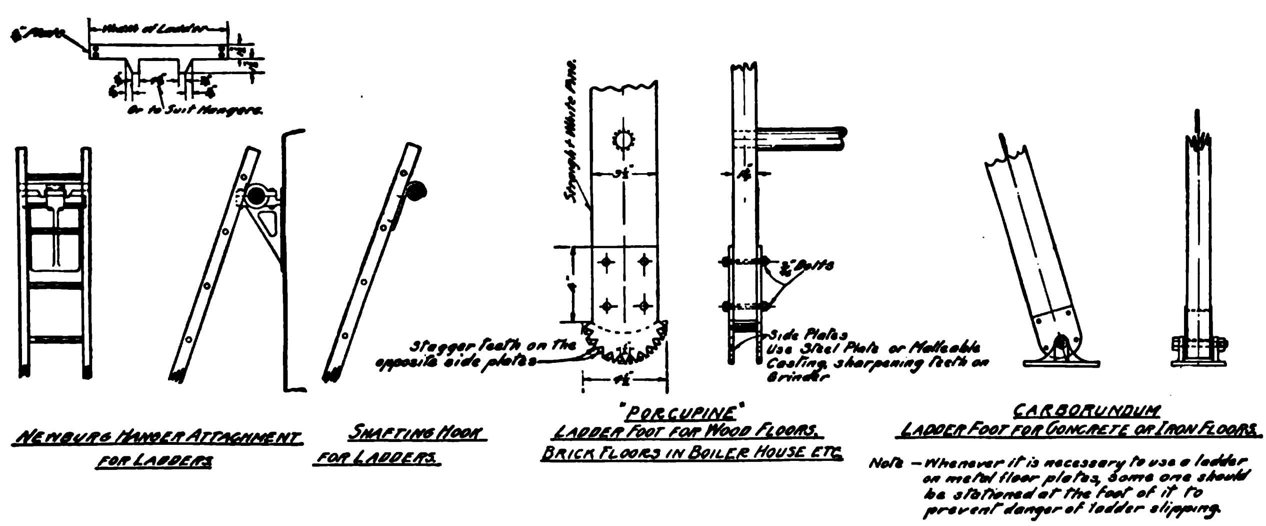


Fig. 2. Safety Feet and Attachments for Portable Ladders.*

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

caged ladder, however, is slight. If a foot slips there is a good chance that the grip of the hands will be maintained; if the hands lose their hold the shoulders merely drop back a few inches until they come in contact with the cage. It is possible for a person to go up and down a caged ladder without using the hands.

The safety condition here is in striking contrast to that of the ordinary unprotected ladder, on which, if it happens to be high, death or serious injury is inevitable if the hands lose their hold; the man then falls back clutching for some support, and turns over and over until he strikes the ground. In a mill, the hand-hold on the rungs is often rendered insecure by grease or dirt from the shoes of persons who have previously used the ladder.

One of the advantages of a safety cage on a ladder is the sense of security which it gives; this makes it possible for even those who are unused to climbing high ladders to do so with safety.

Where gas is liable to be encountered, as at blast furnaces and around gas generating plants, the ladder-cage is particularly advantageous, since it will give a much needed support to the person who feels any dizziness or nausea while using the ladder.

It is sometimes felt that there is little or no hazard to an experienced man in climbing a ladder; this, however, does not necessarily follow, as numerous cases of accidents to such persons are on record.

A characteristic example is that of a crane operator, young, active and thoroughly capable. He had been using the ladder to his crane for more than two years, but one day fell and was killed. At the time of the accident he was descending the ladder with his coat over one arm and a dinner-pail in his hand, using only the other hand to grasp the rungs of the ladder. His experience and assurance led him to take a chance, where a less experienced man would probably have taken the safe course and thus avoided the accident.

The same feeling of assurance may result in accidents to any experienced man, so the ladder hazard may be considered as being practically constant, regardless of experience, and the safety cage is of value to both trained and untrained men.

PORTABLE LADDERS

Where it is necessary to use portable ladders they should be of best selected straight-grained wood, free from knots or other defects. Spruce or white pine is recommended for the stringers. Rungs should be of ash, oak, hickory or other similar wood; they should be approximately $1\frac{1}{4}''$ diameter, and should be set into the stringer and secured from turning or working loose. The practice of constructing ladders by nailing rungs onto the side of the stringers is dangerous, as accidents may be caused by the nails drawing out or the ends of the rungs splitting.

If used for oiling shafting, it is well to provide hooks at the top of the ladder which can be placed over a shaft or hanger. (See Fig. 2, P. 231.) Since oiling is only done at intervals, trucks, piles of stock or other objects are liable to be left in positions which prevent the oiler's ladder being placed at the proper angle; the shafting hooks may prevent accidents from such causes.

"Safety Feet" should be attached to the bottom of each portable ladder. For use on wooden floors a steel plate having a series of sharp radial spurs is desirable. The single spur commonly used is effective so long as the ladder is placed nearly vertical; it is of little value, however, when placed at a considerable angle from the vertical, or so that the tendency is to slip along the grain of the wood. Where the radial or "porcupine" foot is used, if one spike slips another one comes into engagement. The teeth or spurs always make a right-angled contact with the floor, regardless of the angle at which the ladder is placed. (See Fig. 2, Page 231.)

For use on concrete floors, a swiveled metal foot surfaced with an abrasive material such as carborundum or alundum gives good results. Bass-wood and cork surfacing have also been used for this type of ladder-foot, to good advantage.

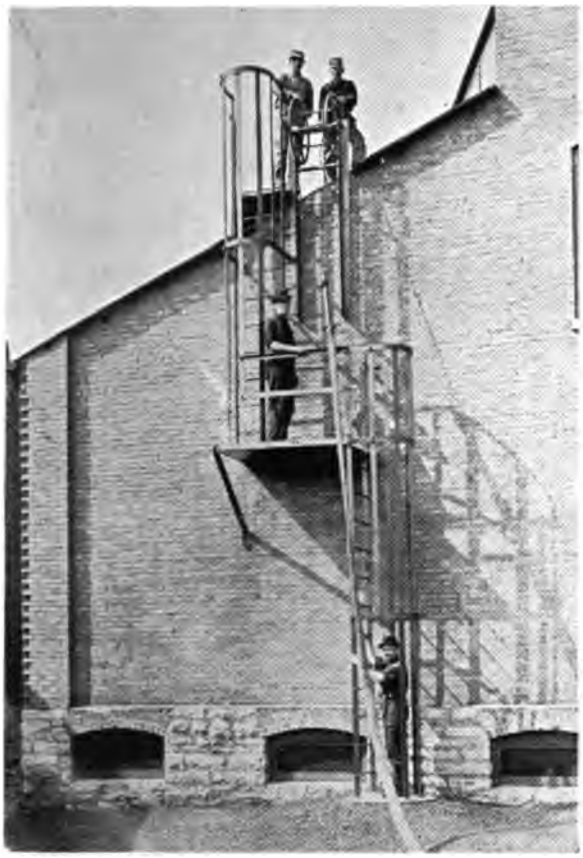


Fig. 1. Fixed Ladder with Safety Cage.*

Fig. 2. Fixed Ladder with Locking Door.*

Fig. 3. Portable Ladder with Safety Feet.*

The ladder-cage shown in Fig. 1 practically eliminates danger of falls from the ladder. The intermediate landing makes it impossible for persons to drop more than a short distance, even though they should fall down the cage. A reel and rope or chain used for quickly raising a line of fire hose to the roof are also shown.

Fig. 2 shows a ladder leading to high-tension electrical apparatus. A swinging door is hinged to one side of the ladder and arranged so it can be locked shut, thus making it impossible for any unauthorized person to ascend the ladder.

The ladder shown in Fig. 3 has "safety feet" of metal surfaced with carborundum. It supported a man when placed at an angle of 35° from the horizontal, on an oily concrete floor.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

The use of portable ladders on metal floors is always liable to cause an accident if the ladder is unattended, since spurs or other "safety feet" cannot be depended upon to secure a hold on such material. Wherever it is necessary to use a ladder on a floor consisting of cast iron or steel plates, a man should be stationed at the foot of the ladder, to hold it in position as long as any one is on it.

Repairs to Old Ladders

It is undesirable to splice or reinforce stringers of portable ladders which have become cracked or broken. In such cases a new stringer should be supplied, or the ladder destroyed or cut into short sections.

Some definite plan should be adopted to make certain that defective ladders will not be used again. Accidents sometimes occur from the use of such ladders which are brought to the repair shop and left where they may be taken and used by other workmen.

In some plants defective ladders are chained to a post in the repair shop and pad-locked in position until they can receive the necessary attention.

SCAFFOLDING

Wherever there is occasion to work at points which cannot be reached from the floor or platform level, safe and convenient scaffolds should be provided. Many accidents are caused by the use of make-shift scaffolding hurriedly erected for some emergency or repair work from the first materials that come to hand.

The Safety Committee of the Illinois Steel Company has prepared an excellent set of "Construction Specifications and Operating Rules for Scaffolds," which are largely followed in the succeeding paragraphs.

Supervision

It is strongly recommended that some individual be made responsible for the scaffolds in each plant, it being the duty of this individual to see that none but safe equipment is used.

Wood for use in scaffolds should be specially selected, straight, close-grained and free from knots, injurious ring-shakes or other defects. (The Illinois Steel Company specifications require that long-leaf yellow pine shall be used exclusively.)

Railings

Railings are recommended for swing scaffolds used 10′ or more above the ground, and for built-up scaffolds 5′ or more above the ground. A guard or toe-board not less than 6″ in height is specified for exposed edges of built-up scaffolds 5′ or more in height. Such guards are also desirable for swinging scaffolds, a good arrangement being to enclose the space between railing and floor with a canvas apron, as indicated in Fig. 1, Page 236.

For moderate heights (say 16′ or less above the floor) the type of staging shown in Figs. 1 and 2, Page 235, is very effective. It can be set up more quickly than a swinging scaffold and in locations where a satisfactory support for the latter is not available.

For greater heights, and for work on the outside of buildings, etc., some form of swinging scaffold (or built-up scaffold) is desirable. A good swinging scaffold is shown in Fig. 3, Page 236. The common practice of making up swinging scaffolds from ordinary portable ladders is liable to cause accidents, unless used with extreme care and good judgment. The tendency is to extend the supports, where a wide scaffold is needed, to a point where the ladder cannot safely carry the required load.

The built-up stage plank shown in Fig. 1, Page 235, is preferable to a ladder of solid plank. Where a solid plank is used, the Illinois Steel Company rules call for not less than 12″ x $1\frac{5}{8}$″ for spans of 12′ or less, and not less than 12″ x $2\frac{3}{4}$″ for spans of 12′ to 24′. A centre support or hanger every 8′ is recommended, and is mandatory where more than two men are to work on the scaffold.

Where swinging scaffolds are made from ladders or where there is any doubt as to the strength of swinging scaffold, it should be loaded while near the ground with at least double the weight it must ordinarily support, so that any weakness will be developed before it is raised into the working position.

Ropes for swinging scaffolds should be care-

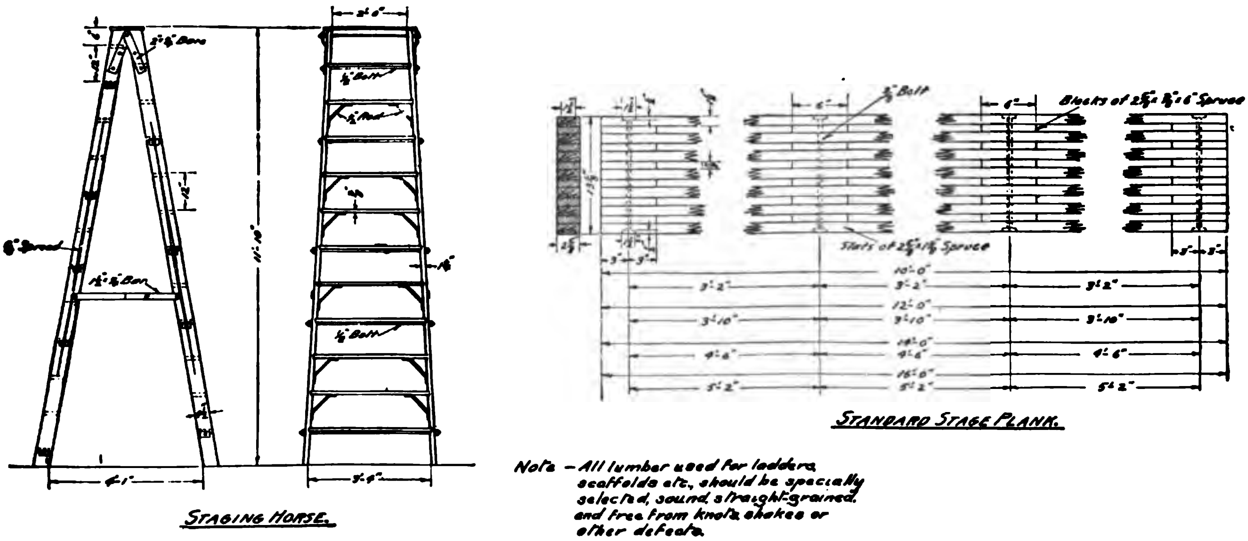


Fig. 1. Safety Staging.*

Fig. 2. Staging, set up.*

Fig. 3. Use of Safety Belt and Line.*

A mill repair gang is often called upon to do emergency work in the shortest possible time. A breaking shaft, hanger, main belt, steam pipe, etc., may shut down an entire plant, so that every minute's delay means a serious loss.

Under these circumstances, improvised scaffolds of unsafe or improper construction are often erected. Figs. 1 and 2 illustrate a form of staging which can be set up in two or three minutes time, giving a light, and at the same time rigid arrangement, which permits men to work safely at any height up to sixteen or seventeen feet from the floor.

The built-up construction of the stage plank makes it lighter for a given strength, or stronger for a given weight, than a solid plank; furthermore, its strength is not seriously impaired by a single knot or other defect. This construction makes the plank easily identified, so it is not likely to be appropriated for other purposes, — a difficulty with which the repair gang has to contend constantly.

Fig. 3 shows a safety belt and rope used for work on a roof. Safety belts should also be used for window-cleaning or other work where there is danger of persons falling.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

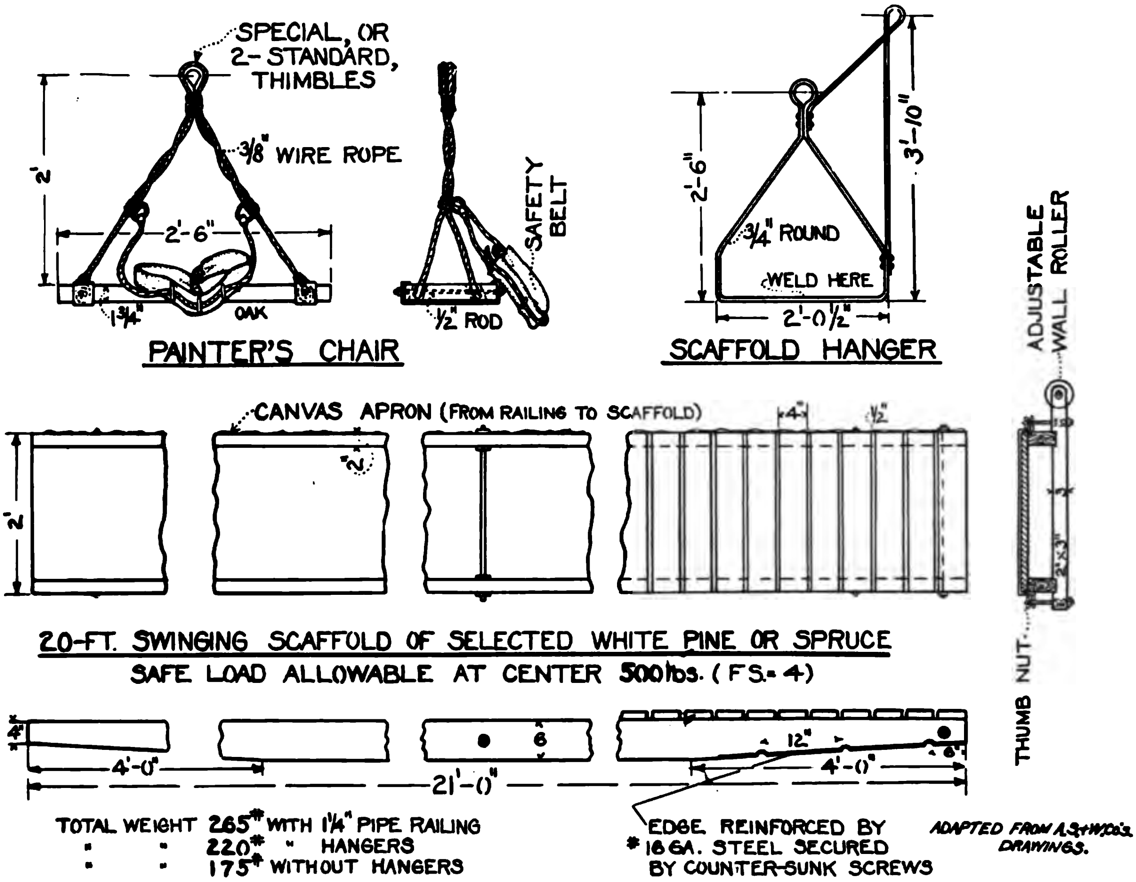


Fig. 1. Swinging Scaffold and Painter's Chair with Safety Belt.

A good design for swinging scaffolds of wide span is shown in Fig. 1. This will safely support the weight of three men. Safety belts should always be used with painter's chairs.

Fig. 2. Unsafe Scaffold Practice.

Men working at eleventh story of building, without railing, and using box to increase reach.

Fig. 3. Approved Scaffold for Building Construction. (Pat.)

Space between railing and floor might well be enclosed with wire netting or other material.

fully inspected at frequent intervals to make sure that they are in good condition at all times. As soon as a rope shows appreciable wear or damage it should be discarded (and destroyed or otherwise definitely disposed of, to prevent the possibility of its being used again).

The Illinois Steel Company rules recommend wire rope for swinging scaffolds in preference to manila. Wire rope is to be of plow steel, six-strand, nineteen wires, and not less than one half inch diameter. Manila rope for such service should be of best long fibre grade, at least 1″ diameter, and double-lashed at each point of suspension.

Ropes should never be loaded beyond the amounts specified in table of safe loads on Page 244.

Ropes should be protected by bagging or wooden blocking at any points where they come in contact with sharp edges which might cause injury. Where rope used to support scaffolding must be carried close to railroad tracks, roads, passageways, fires, etc., which might injure or interfere with the safe operation of the rope, a workman should be provided to guard it.

Hooks used for swinging scaffolds should be of safety type, — that is, — they should be so arranged as to prevent danger of a hook coming loose, through tangling or fouling of the rope or some other mischance. Fatal accidents have occurred from this cause. A good type of safety hook for the upper support of swinging scaffolds is shown in Fig. 5, Page 243.

Another way to avoid danger of hooks coming loose is to substitute a clevis attachment, fastened by a bolt and cotter-pin (see Fig. 1, Page 241), for the hook.

For the construction of high buildings, where a continuous line of scaffolding along the side of the building is required, the type of scaffold shown in Fig. 3, Page 236, gives excellent results. The entire line of scaffolding can be raised or lowered uniformly, by winding or unwinding the suspension cables on the drums. This device has been examined and approved for safety by the Underwriters' Laboratories.

Scaffolding built-up from the ground is not recommended for buildings of more than three or four stories in height. Such scaffolding should be constructed by thoroughly skilled and competent carpenters only, with a proper knowledge of the ability of the material which is being used to support the required load.

The Illinois Steel Company standards specify material not less than 4″ x 4″ for uprights of built-up scaffolding not exceeding fifty feet in height. Where the framework is to be more than 50′ in height (and less than 100′) the uprights for the lower 50′ are to be reinforced with additional 2″ x 4″ sections. Horizontal members are to be of not less than $1\frac{5}{8}$″ x 12″ material throughout, — diagonal bracing not less than 1″ x 6″.

The flooring of scaffolds should be nailed, bolted or otherwise secured in place. Many accidents have been caused by unsupported ends of planks projecting over stringers, giving way under the weight of a workman and letting him drop to the ground.

Temporary scaffolding should be removed as soon as the work for which it was used has been completed. If left in position, such scaffolding is liable to become warped or misplaced in the course of time, so that persons attempting to use it will fall and be injured.

Special scaffolds for use in erecting or repairing stacks, relining blast furnaces, etc., are well described and illustrated in the Illinois Steel Company's book of specifications and rules.

CHAPTER 25

ROPES, SLINGS, CHAINS, HOOKS, ETC.

WIRE ROPE

For any service where safety is of paramount importance, such as elevators, cranes, etc., wire rope should be used in preference to hemp rope or chains.

The strength of wire rope can be computed with greater accuracy. Its length is constant under varying weather conditions. Its strength is the same whether wet or dry, and it is exceedingly durable. In all of these respects, wire rope is superior to hemp.

The maxim that a "chain is no stronger than its weakest link" has a vital meaning when human lives may be endangered if the chain should break. A chain gives way suddenly and without warning, whereas a wire rope, under ordinary service conditions, always shows signs of approaching failure by broken wires before there is any serious danger. Even when it is stressed to the breaking point, as in a testing machine, an indication of the maximum load is given by the snapping of a few wires before the cable actually breaks.

The wire used in making cables is one of the strongest materials (for a given weight or cross section) available for engineering purposes. The best grades have a tensile strength of 250,000 to 280,000 ℔s. per square inch, or more than four times that of good boiler plate, rivet, or chain steel.

These characteristics have resulted in the adoption of wire rope for a great variety of uses. It should be specified for all new cranes, elevators, etc., and it is worth while to change over equipment already in service, from chains to wire rope.

A general knowledge of the types, grades, construction, etc., of wire rope is of value to the safety inspector. An excellent treatise on this subject, "American Wire Rope," is published by the American Steel & Wire Company, by whose courtesy the following information is given. Particular attention is directed to the rules for socketing or attaching wire ropes; it is self-evident that the value of a good rope will be lost unless the connection is approximately as strong as the rope itself.

The materials from which wire ropes are made have the following nomenclature: —

Iron, which has a tensile strength of 75,000 to 100,p00 ℔s. per sq. in.

Crucible Steel, which has a tensile strength of 150,000 to 220,000 ℔s. per sq. in.

Plow Steel, which has a tensile strength of 200,000 to 280,000 ℔s. per sq. in.

To obtain the approximate strength of ropes, in tons, from diameters, in inches, the following rules may be used: —

Iron rope, — diameter squared x 15.

Crucible Steel Rope, — diameter squared x 32.5.

Plow Steel Rope, — diameter squared x 40.

Rope Constructions

(1) 6 x 7 rope means 6 strands of 7 wires each, usually called Haulage or Standing Rope.

(2) 6 x 19 rope means 6 strands of 19 wires each, called Hoisting Rope.

(3) 6 x 37 rope means 6 strands of 37 wires each, called Crane Rope.

(4) 8 x 19 rope means 8 strands of 19 wires each, called Extra Flexible Rope.

(5) 6 x 6 x 7 rope means 6 ropes of strand, strands of 7 wires, usually called Tiller Rope.

Ropes are generally made with a hemp or Manila centre. For some special purposes, such as hot metal cranes, special wire centres are employed. These are made of soft iron, or a small wire rope is inserted instead of the hemp core. A properly constructed wire centre is composed of at least 6 or 7 strands of 7 wires and not of one strand of 7 or 19 wires as the case may be.

Construction No. 1 (6 x 7) is used principally on mine haulage and guy ropes, where greater strength is required than is found in the ordinary 7-wire strand.

Construction No. 2 (6 x 19) is used for general hoisting purposes, — the iron grade principally for elevator work, — the crucible and plow steel grades for elevators and general purposes.

Construction No. 3 (6 x 37) is used largely for cranes in steel mills and similar work. It is regularly made in two qualities, one with plow steel inside and crucible outside, and the other composed of all plow steel.

Construction No. 4 (8 x 19) is sometimes used on cranes and derricks, and, to a small extent, on ore handling apparatus.

Construction No. 5 (6 x 6 x 7) is used principally for hand rope on elevators, in sizes $\frac{1}{2}''$ diameter.

Diameters of Sheaves and Drums

It should be noted that with the increase in the number of wires, the diameter of sheave that may be used decreases; so also does the ability to withstand abrasion or corroding action decrease.

The following figures may be considered as giving the minimum diameter of sheaves for the different constructions of rope involved. In a few cases, sheaves are of smaller diameter, but the use of such small diameters is questionable and larger ones should be used wherever possible, as they increase the life of the rope.

For 6 x 7 rope, the diameter of sheave should equal 60 times diameter of rope.

For 6 x 19 rope, the diameter of sheave should equal 40 times diameter of rope.

For 6 x 37 rope, the diameter of sheave should equal 27 times diameter of rope.

For 8 x 19 rope, the diameter of sheave should equal 27 times diameter of rope.

For 6 x 6 x 7 rope, the diameter of sheave should equal 20 times diameter of rope.

Inspection of Wire Ropes

Wire rope should be inspected at regular intervals, and a record kept of the inspection. The principal points to be noted are as follows: —

Number of broken wires, if any.

Amount of external wear.

Any local trouble such as would be caused by kinks, etc.

Ropes ordinarily fail gradually by the wearing down and breaking of the wires. A few scattering broken wires may be neglected, but any considerable number broken in one place, due to local injury or otherwise, may render it necessary to replace the rope. No general rule can be laid down for the discarding of a rope, as it is entirely dependent upon the risk involved if the rope should break. Where life or limb is not endangered by the breaking of a rope, it can be run much longer than with elevators, hot metal cranes, etc., where the risk is great. Ordinary ropes may be run until, within a length of three feet, there can be counted broken wires, not exceeding the following amounts for the following constructions: —

6 x 7	5	broken	wires
6 x 19	10	"	"
8 x 19	12	"	"
6 x 37	15	"	"

Rope Fastenings and Attachments

For fastening the ends of ropes, one of the three following methods should be used: —

No. 1, Sockets, which may be either open or closed. (Figs. 1 and 2, Page 241.)

No. 2, Thimbles, spliced in and served with wire. (Figs. 3 and 6, Page 241.)

No. 3, Thimbles, inserted and held in place by at least two clips or at least one three-bolt clamp. (Figs. 5 and 6, Page 241.) If used for attaching the hoist rope to elevator car (which is not recommended) there should be not less than three clips or two clamps for each rope.

If properly made, the socket connection

No. 1 is most secure. It is commonly employed where wire ropes are being tested for tensile strength, and the rope breaking between the sockets indicates an efficiency of 100 per cent for this type of fastening.

It is most important, however, that the sockets be attached in the proper manner, as described in the following

Directions for Attaching Sockets to Wire Rope

First. — The rope should be securely seized at the end before it is cut off, and additional seizing should be placed at a distance equal to the length of the basket of the socket away from the end. In the case of large ropes, this seizing should be several inches long, and it should be securely wrapped on with a special seizing iron. This is very important, in order that the lay of the rope should not become untwisted, otherwise the tension on the strands may not be equal when the socket is applied.

Second. — The end seizing on the rope should be removed, leaving the rope free for a distance equal to the length of the socket basket. The hemp centre back of this seizing should then be cut out, and the wires should be broomed out straight, i.e., they should be all untwisted, not necessarily straightened.

Third. — The wires for the distance that they are to be inserted in the socket should be carefully cleaned in benzine, naptha, or gasoline, and then dipped in a bath of commercial muriatic acid for a period of about fifty seconds to one minute, or until the acid has thoroughly cleaned each wire. The inside of the socket should be similarly cleaned and the surface brightened or roughened.

Fourth. — The wires should be dipped in boiling hot water to which has been added a small amount of soda to neutralize the acid, then dried thoroughly and inserted in the socket. The ends of wires should be turned in before the rope is drawn down into the basket of the socket, and carefully aligned with the axis of the socket. The latter, and the end of the rope inside it, should be thoroughly warmed so that it will not chill the hot metal which comes in contact with it and prevent its proper distribution; this also makes certain that all moisture is removed, avoiding danger of the molten zinc flying when it is poured.

Fifth. — The base of the socket basket should be sealed (from the outside) with putty, clay, or some similar substance, and molten zinc poured into the basket until it is full. The zinc must not be too hot or it will anneal the ends of the wires, particularly on smaller ropes. About 700 to 800 degrees F. should be sufficiently hot. When congealed, the socket can be plunged into cold water to cool off. (If socketing is properly done, the wire rope, when tested, will break between the sockets.)

The metal used for wire rope socketing should be a high grade commercial zinc. When attaching a $\frac{3}{4}''$ socket to a $\frac{3}{4}''$ wire rope, about $2\frac{1}{2}$ pounds of zinc is sufficient for one socket. This zinc is placed in a melting pot and heated on a plumber's furnace. To determine when the metal has reached the proper temperature for pouring, the "stick" method is the one most commonly used. A dry, soft pine stick, when dipped into the hot metal and quickly withdrawn, must not have any zinc adhering to it, neither should it show any signs of being very much burned or charred. If the metal adheres to the stick, it is too cold for pouring; if the stick appears to be badly burned, the metal is too hot. The exact mean when the stick shows no sign of metal adhesion or of burning or charring indicates the desired temperature.

Lubrication

Wire ropes frequently fail from lack of lubrication. They are commonly made with lubricated core, but in addition to this, suitable lubrication should be supplied at regular intervals, depending upon the character of the work. The nature of the lubricant should vary with the conditions of service. For elevator work, linseed oil or something of about the same consistency should be used. For outside work, a graphite grease or heavy oil should be employed. In any case, the lubricant should be free from acid.

Fig. 4. Cable Slings, Hook Attachments, etc.

Fig. 1. Open Socket.

Fig. 2. Closed Socket.

Fig. 3. Thimble spliced in and served with Bire.

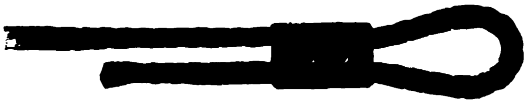


Fig. 5. Three-Bolt Clamp.

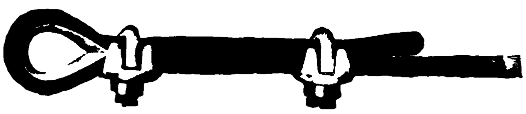


Fig. 6. Thimble secured by Clips.

Wire Rope Slings. (See Pages 241, 243 and 245.)

For handling heavy machinery, heavy castings, etc., wire rope slings should be used. These are made in various ways and consist usually of short pieces of rope with thimbles or sockets spliced securely in the ends. Care should be exercised in using slings to see that, if bent around sharp corners, such corners are protected by means of burlap or some similar substance.

Wire rope should not be permitted to kink, as kinking is liable to break a rope under a very low stress.

Safety Factors for Wire Rope

It is recommended that the minimum factor of safety for any class of work be 5, based on the rated strength of a new rope. On elevators, hot metal cranes, etc., the factor of safety as a rule should be 8 or higher. In general, the factor of safety should be governed by the character of the work. Where people are carried, as in elevators, or where material is handled that would be dangerous if a rope broke, the factor of safety should be conservatively high. There may be occasional times when a heavy piece of steel or cold material has to be lifted once only; in such cases, if the rope is practically new, it can be stressed so that the factor of safety comes down to 4, but this is not recommended, and suitable precautions should be taken at such times to prevent accidents if the rope should break.

Use of Ropes in Multiple

Safety in the use of ropes is not dependent on the *factor of safety* alone. The question of attaching the end of the rope is equally important, and more difficult to control from the practical standpoint. For example, in elevator installations conditions are frequently encountered where the failure of any one of several members (pins, bolts, forgings, etc.) might detach the rope entirely. It is accordingly desirable to use two or more ropes with independent fastenings, wherever practicable, in preference to one rope with a single fastening.

CHAINS

As already mentioned, the use of chains for cranes, elevators and similar service where their failure may cause fatal accidents is poor practice, — wire cables giving better safety conditions. Where chains are used, special precautions should be taken to guard against their failure.

Chain manufacturers ordinarily "prove" welded chains by subjecting them to a tensile stress of about one-half their ultimate strength, as shown by breaking tests of the chains. They recommend that the loads which the chains are called upon to lift in actual service should not be greater than one-half the proof test. This would give a factor of safety of about four.

The conditions which affect the strength of a chain are difficult to determine accurately. If the material in it is crystallized, the strength of the chain will be seriously impaired. A fracture may start in any link which will develop progressively until the chain finally fails under a load much below its rated capacity. Even the makers' proof test may start such a fracture, and the chain not fail immediately; from this standpoint the application of a proof load is undesirable, but it seems to be the only practical way of making sure that there are no serious defects in the links, such as imperfect welds, etc. Abnormal stresses may be caused by shocks resulting from the load slipping, or from the sudden tightening of the chain. On account of these indefinite elements, a higher factor of safety than four should be used for chains in important service, — six to eight being preferable.

The annealing of chains about once in six months is desirable, ***provided*** such annealing is done with the proper facilities for accurately determining and regulating the temperature. The practice of throwing chains into a heating furnace ordinarily used for some other purpose or into an open fire, without the use of a pyrometer, is to be condemned, and is almost certain to result in accidents, sooner or later. Crystallization may occur from the application of either too high or too low temperatures, thus

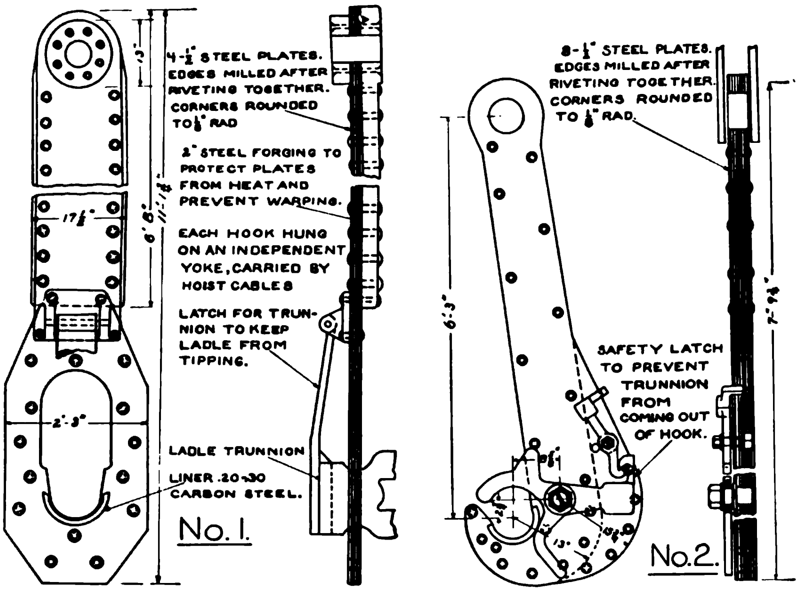


Fig. 1. Laminated Safety Hooks for Hot Metal Cranes.*

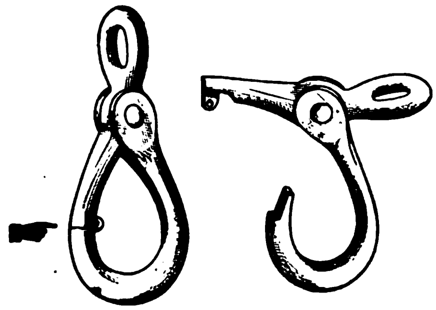


Fig. 2. Safety Hook.

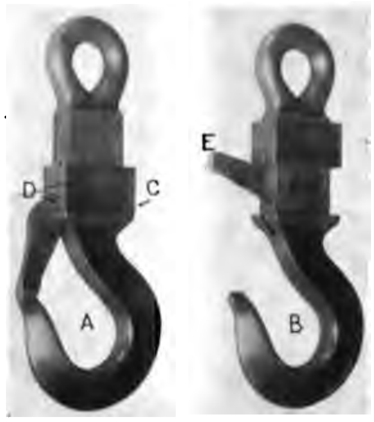


Fig. 3. (Courtesy National Tube Co.)

Fig. 4. Crane Hook with Handle.*

In Fig. 1, construction No. 1 and the latch in No. 2 prevent danger of hook releasing accidentally.

The arrangement shown in Figs. 2 and 3 prevent hooks from catching or becoming unhooked; that of Fig. 2 also reinforces hook at point.

Fig. 5 shows an arrangement to prevent hooks used with swinging scaffolds from coming loose.

Fig. 5. Hook for Scaffolds.*

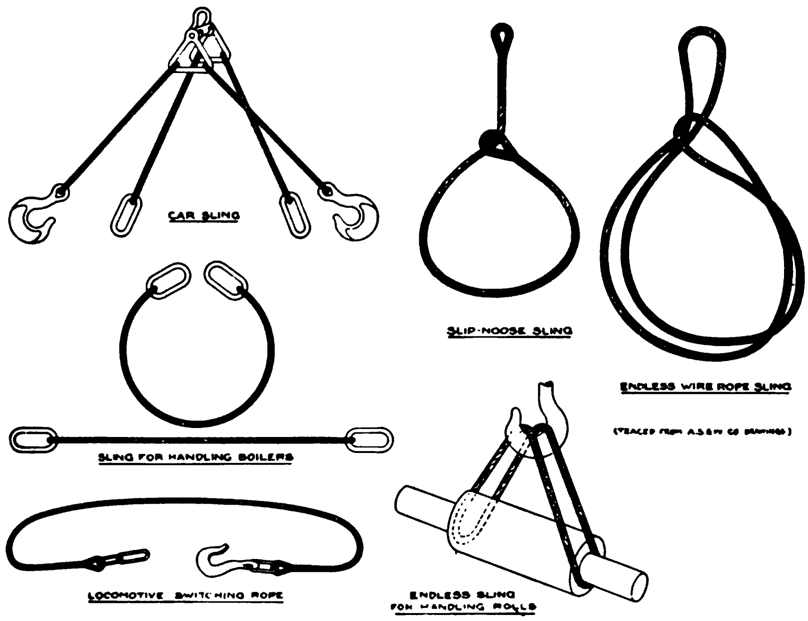


Fig. 6. Types of Wire Rope Slings, adapted to Various Kinds of Service.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

weakening the chains rather than helping them. (See Chapter 16.)

When a chain breaks, it is best to discard it if it shows material signs of wear. If not worn a new link may be welded in, after which the chain should be carefully annealed to avoid crystallization from critical heating. (See Page 153.) A broken chain should never be mended by bolting two links together, as is sometimes done, since this gives a weak joint which may give way at any time.

Chains should be kept well lubricated, — otherwise they will soon be weakened by wearing of the links. They should not be dragged on the ground or floor, as this wears them out rapidly. Kinking the chain under load should be avoided as this may cause it to break without warning.

SAFE LOADS FOR ROPES AND CHAINS

It is very desirable to have a table or sign showing safe loads for ropes, chains, etc., posted where employees using such equipment can familiarize themselves with it. The obliquity of a sling has a marked effect upon its ability to safely carry a given load. This point is likely to be lost sight of unless it is strongly impressed upon the men.

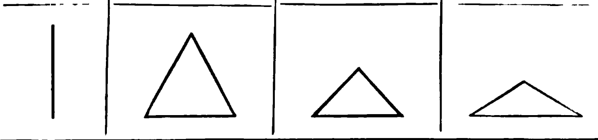
The following table was prepared by the National Founders' Association and issued by them in Bulletin No. 13, dated June 1, 1914. In a number of plants this data has been embodied in an enlarged tracing, blue prints of which are furnished to those interested.

Safe Loads (in pounds) for Ropes and Chains

Caution. When handling molten metal, wire ropes and chains should be 25% stronger than indicated in table.

Note. The safe loads in table are for each SINGLE rope or chain. When used double or in other multiples the loads may be increased proportionately.

When used straight	*When used at 60° angle*	*When used at 45° angle*	*When used at 30° angle*



PLOW STEEL WIRE ROPE

(6 strands of 19 or 37 wires)

If crucible steel rope is used reduce loads one-fifth.

Dia.	*Straight*	*60° ∠*	*45° ∠*	*30° ∠*
3/8″	1,500	1,275	1,050	750
1/2	2,400	2,050	1,700	1,200
5/8	4,000	3,400	2,800	2,000
3/4	6,000	5,100	4,200	3,000
7/8	8,000	6,800	5,600	4,000
1	10,000	8,500	7,000	5,000
1 1/8	13,000	11,000	9,000	6,500
1 1/4	16,000	13,500	11,000	8,000
1 3/8	19,000	16,000	13,000	9,500
1 1/2	22,000	19,000	16,000	11,000

CRANE CHAIN

(Best Grade of Wrought Iron, Hand-Made, Tested, Short-Link Chain)

Dia. of iron	*Straight*	*60° ∠*	*45° ∠*	*30° ∠*
1/4″	600	500	425	300
3/8	1,200	1,025	850	600
1/2	2,400	2,050	1,700	1,200
5/8	4,000	3,400	2,800	2,000
3/4	5,500	4,700	3,900	2,750
7/8	7,500	6,400	5,200	3,700
1	9,500	8,000	6,600	4,700
1 1/8	12,000	10,200	8,400	6,000
1 1/4	15,000	12,750	10,500	7,500
1 3/8	22,000	19,000	16,000	11,000

MANILA ROPE

(Best Long Fibre Grade)

Dia.	*Straight*	*60° ∠*	*45° ∠*	*30° ∠*
3/8″	120	100	85	60
1/2	250	210	175	125
5/8	360	300	250	180
3/4	520	440	360	260
7/8	620	520	420	300
1	750	625	525	375
1 1/8	1,000	850	700	500
1 1/4	1,200	1,025	850	600
1 1/2	1,600	1,350	1,100	800
1 3/4	2,100	1,800	1,500	1,050
2	2,800	2,400	2,000	1,400
2 1/2	4,000	3,400	2,800	2,000
3	6,000	5,100	4,200	3,000

Fig. 1. Racks for Slings and Chains.*

Where racks such as are shown in Fig. 1 are used, the equipment can be more readily located, floor space is saved and stumbling accidents are prevented. The racks also protect the chains and slings from injury and, to a certain extent, from corrosion.

Hooks are badly strained when loads are carried on their points, as illustrated in Fig. 2. The hooks are also apt to jar off and drop the load. Steel eye rings should be permanently attached to sides of flasks for entrance of hooks.

Fig. 2. Load on Point of Hooks.*

Fig. 3. Fig. 4.
Wrong Methods.*

A single rope, as used in Fig. 3, may uncoil and loosen the splices. The sharp corners are also apt to cut the wires.

It is impossible to make two slings, when used as illustrated in Fig. 4, of equal length, hence the shorter must carry the entire load.

Fig. 5 shows same sling as Fig. 3, doubled. Bagging prevents injury from sharp corners.

One long sling (Fig. 6), doubled, equalizes the load. It is easier to apply, stronger and safer than the arrangement shown in Fig. 4.

Fig. 5. Fig. 6.
Right Methods.*

*** The above photographs are reproduced, by permission, from the "N. F. A. Safety Bulletin," Number 13, June 1, 1914, published by the National Founders' Association, to whom indebtedness is acknowledged by the author.**

HOOKS

In some kinds of service, such as handling ladles of molten metal, hooks have a very important relation to human safety. This has resulted in the development of a laminated hook, made of steel plates riveted together, which is used on hot metal cranes in some of the large steel plants of this country. (See Fig. 1, P. 243.)

A laminated hook has the same advantage, in comparison with one forged from a single piece, that a wire cable has, to a chain; it is made up of a number of sections, the strength of which can be determined with considerable accuracy, and a defect in any one of which will not materially reduce the total strength of the hook.

In some locations there is danger of a crane hook catching in the building framework or other adjacent structures; serious wrecks may be caused in this manner. The hooks shown in Figs. 2 and 3, Page 243 overcome this difficulty, and they also provide against danger of the object becoming unhooked accidentally.

The use of a handle, such as is shown in Fig. 4, Page 243, is an excellent expedient for preventing injuries to fingers of "hookers on."

For swinging scaffolds it is important that the hooks should be not only of adequate strength, but so arranged that they are not liable to come unhooked and permit the scaffold to fall. The type of hook shown in Figs. 2 and 5, Page 243, are desirable from this standpoint.

For specifications of material to be used in hooks, and for a discussion of annealing, etc., see Chapter 16.

CHAPTER 26

IRON AND STEEL WORKS

THE word "safety," used in connection with the iron and steel industry, instantly suggests the United States Steel Corporation. This Corporation is a pioneer, not only in its own particular industry, but in the general safety movement in this country as well. As a result of the work which it has done, accidents to its employees have been reduced approximately 40 per cent, and more than 11,000 men have been saved from death or serious injury during a period of seven years. (See chart in Chapter 2.)

Some of the principal safety rules adopted by the Corporation have been standardized by its Committee of Safety, and the data relating particularly to the equipment of the iron and steel industry is reproduced herewith. Provision is made in the rules for the protection of gearing, belting, set screws, etc., but the sections relating thereto are omitted, since they are covered at greater length elsewhere in this volume.

"**BLAST FURNACES**

(a) Each blast furnace shall be equipped with a telephone or speaking tube between the skip hoist operator's house and the blower's office. One shall also be installed near top of furnace for use of signalmen or men engaged in constructing or repairing top of furnace.

(b) Platforms, properly railed and equipped with toeboards, shall be installed at all elevated points where employees are required to go regularly for oiling or other purposes. Platforms shall be provided at the steam or air cylinders for the bells. All such platforms, when exposed, shall be roofed, to protect the men from 'slips.' Permanent iron ladders or stairways shall lead to these platforms.

(c) Approved eyesights shall be installed on all tuyeres.

(d) The mud gun shall be equipped with a funnel-shaped casting over the receiving hole of the mud cylinder, also with shield to prevent hot metal burning the workmen.

(e) Platforms, properly railed, shall be provided for all explosion doors.

(f) Explosion doors shall be so built that nothing but gas and fine ore can escape from the furnace.

Cast House, Etc.

(g) Casting holes where ladles are loaded under the floor, shall be grated or railed.

(h) Egress from cast houses shall be provided by runways or stairs of ample width at the ends or sides of each cast house. The elevated floor of the cast house shall be properly railed.

(i) A shield shall be provided for the tapping hole, so designed and constructed that a hole no larger than that required for the movement of the drill is left open.

(j) Cinder notches shall be provided with shields, which can be used to protect men botting in the cinder notch.

(k) Gates in iron and cinder runners shall be operated from such a distance that men operating the gates will not be in danger of being burned.

(l) All gas washers and gas mains used in connection with gas washers, which may have to be cleaned, shall be provided with valves at each end of the system, by which they may be completely shut off so as to avoid danger of explosion.

(m) All blast furnaces shall have railed walks, with toeboards, on the bustle pipes, with stairs or stationary steel ladders leading to them.

(n) The outrigging on all blast furnaces shall be equipped with a runway, with proper railing and toeboard.

(o) A steel roof shall cover all points where men work around a blast furnace. The sheeting on the sides of the cast houses shall come down far enough to prevent storms beating in, or stock being thrown in by 'slips' of other furnaces; and hoisting machinery, cranes, etc., near a blast furnace shall be roofed to protect men from falling material in case of slips.

(p) A small house shall be provided on top of a furnace, or on a runway by the furnace, to protect men from 'slips.'

Hot Blast Stoves

(q) All stoves shall be connected by railed walks, built with solid bottom and guard plates at least twelve inches high.

Blowing Engine House

(r) To prevent mistake in distinguishing the sound of similar whistles, the number of the furnace from which the signal is blown shall be shown in the power house by a light, visible to the engineer.

(s) Signal whistles in blowing engine room shall be blown by electric power, operated by switches in cast houses, and a telltale light shall be located at the switch to show when circuit is made.

Stock Yards and Stock Bins

(t) Ore bridge trolley cabs shall be equipped with brakes, air whistles or gongs, and with safety switches located on top of cab.

(u) Safety switches shall also be installed at each end of bridge between trucks, to cut off all power from each set of truck gears. Trucks must be provided with automatic brakes.

(v) In handling of stock from pockets, the bottoms of which are formed by drums, gates must be installed over the drums to prevent material falling on car operator.

(w) Pockets of any kind shall be shielded so as to prevent material dumped from above running through the pocket and injuring employees in the alley below.

(x) All scale cars and transfer cars shall be equipped with air brakes, fenders and gongs which ring continuously while the car is moving.

(y) The skip pit shall be so constructed that there will be ample clearance for a man on all sides of the skip car. All skip pits which cannot be entered at bottom level shall be equipped with stairs. Where openings are made in stock trestle to accommodate skip they shall be guarded.

(z) Skip car track shall have a shield on under side from the top of furnace, terminating in a chute near the base of the skip.

(aa) Bins used for flue dust must be provided with heavy cast iron knife edge sluice gates, adapted to cutting off hot dust.

(bb) Sprinkling arrangement shall be installed at all dust catchers, so as to wet the dust thoroughly as it is emptied into car.

(cc) Operating devices for dust catchers shall be provided, which will enable employees to dump these from a sufficient distance to avoid possible burning by the hot dust. The down-legs shall be low enough to prevent scattering of the dust.

BESSEMER DEPARTMENT

Pig Iron Yard

(a) All workmen in pig iron yard should wear hand leathers of approved design. (See Fig. 2, P. 263.)

(b) Suitable provision shall be made to protect men from flying pieces of pig iron when cars are being unloaded.

(c) There should be division walls in piles of pig iron, to prevent iron from tangling and making dangerous piles; also to protect stokers from flying pieces of pig iron when cars are being unloaded in other bins.

(d) Metal barrow beds should be made large enough to hold the load safely, to prevent the danger of pigs falling off.

Iron Cupolas

(e) Cupolas shall be covered at charging floor when liners are working in cupolas, to prevent chargers throwing material into cupola or brick falling from stacks on men. These covers should be made of heavy wire grill-work, to allow ventilation for men working in cupolas. (See Fig. 3, P. 257.)

(f) Section of cupola just below charging floor shall be made of cast steel, so that it will not warp and allow scrap and other material to fall through between cupola and charging floor.

(g) Drop chutes shall be enclosed as completely as possible, a 4-inch hole being ample to place bar for knocking out props. Where practicable, the props should be pulled by means of snatch block, cable or locomotive, rather than by hand.

(h) When cupola cinder is run in runner through floor, this hole should be provided with a shield of sufficient height to prevent workmen from stepping into it.

(i) In the Cupola Building, on the dumping floor, protection shall be provided for the men dumping the cupola.

(j) All ladles shall be bottom heavy, and so constructed that when locks are out of place ladle will not upset.

(k) All mixers shall be counterbalanced, so that if pressure is off tipping cylinder the mixer will return to an upright position automatically. Next to the operating valve on pressure pipe to front of tipping cylinder, shall be placed a cut-off valve which will cut off the pressure from cylinder and open it to the discharge, so that counterweights may bring mixer to its upright position, and not be held by water in cylinder. This valve is to be used only in case of emergency.

(l) Hydraulic cylinder under mixer shall be protected by steel plate, covered with fire brick.

(m) A warning bell shall be installed, to be rung by pourer before pouring a heat.

(n) Safe means of escape shall be provided for men working on mixer platform.

(o) It is recommended that in place of using a short chain on auxiliary for dumping ladle, a cable fitted with ring and hook be used for this purpose, as links of chain sometimes twist, giving ladle a sudden jerk which is liable to cause a spill.

Fig. 1. Safety Provisions at Blast Furnace, American Steel and Wire Company.* Fig. 2.

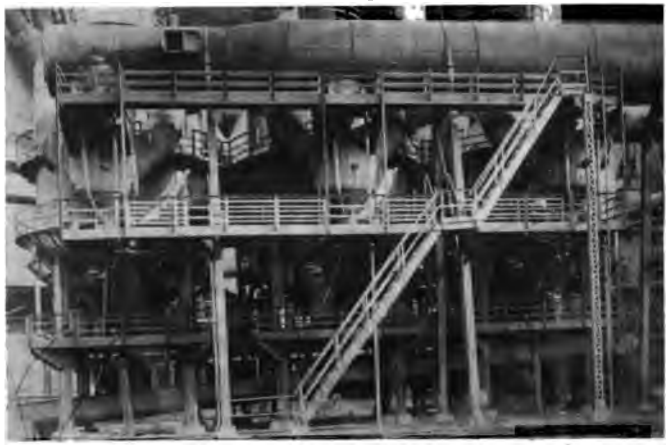


Fig. 3. Blast Furnace Dust-Catchers, etc., Illinois Steel Co.*

Figs. 1 and 2 show a thin-lined blast furnace. This is provided with railed galleries connected by stairways, from which the cooling plates and water piping, etc., may be safely reached throughout the entire height of the furnace. Fixed platforms are provided at all sheaves, manholes and other locations where it is necessary for men to work. Note predominance of stairways; where it is necessary to use ladders they are fitted with safety cages. The walk at the corner of the cast house (Fig. 1) gives access to the crane runway inside. A walk also extends to the comb of the cast house roof, from which rigging can be lowered for repairing the roof, etc.

Fig. 3 shows an excellent arrangement of stairways, walks, platforms, etc., around blast furnace dust-catchers and piping.

* Subsidiary of United States Steel Corporation.

(p) Auxiliary hoist of ladle crane shall be equipped with a hook which can be attached by the crane-man, to tip ladle after the ladle has been hoisted to the pouring position.

(q) Where knuckle jointed arm is used for dumping iron ladle, it shall be covered with leather or other material as a guard against protruding bolts and nuts.

(r) Where plunger elevators are used for hoisting metal to mixer elevation, the hoist shall be equipped with safety dogs.

(s) Where plunger elevator is used to convey iron to mixer, the opening in the floor caused by raising the hoist shall be protected.

(t) All cages on hot metal cranes shall be arranged so as to give ample protection to cranemen in case of spilling or dropping a ladle of hot metal. Each crane shall have a sheet iron closet lined with asbestos, to be used by cranemen in case anything goes wrong with machinery when hoisting hot metal.

(u) Automatic rail stops shall be placed on either side of opening of hydraulic hoists conveying iron to mixers.

(v) Guards shall be placed in front of truck wheels, and an automatic alarm shall be installed on mixer iron transfer ladle.

(w) There shall be a signal system between mixer, pourer, and operator of transfer ladle, to notify operator when heat is poured and ladle is ready to move.

(x) The uncapping stand shall be equipped with sliding doors, or railed off to such a distance as will allow the proper cooling of ingots before they can be uncapped.

Vessels

(y) A warning whistle shall be provided to give warning when vessel is to be tipped.

(z) Bells shall be placed under vessels, rung from scrapping floor, to warn slag-men that vessel is about to be scrapped; bell shall also be rung when scrapping is finished.

(aa) When new vessels are being installed, or when making repairs or replacements that would justify the cost, vertical outside packed plungers should be provided, thereby doing away with inside packing.

Steel Cranes

(bb) Safety catches or stops shall be placed on jibs of all steel cranes to prevent ladle running off the end of jib.

(cc) Steel cranes shall be equipped with an automatic safety device that will hold crane jib and ladle suspended over molds, regardless of failure of pressure or any other cause.

Ladles

(dd) All ladle trunnions shall be drilled and tested before being placed in service.

Pouring Platform

(ee) A side lever for pouring steel is recommended, as being much safer for the men than pouring from directly in front of the ladles.

(ff) Pouring platform shall be amply large, and provided with a number of exits to allow men to escape in case of accident.

(gg) All platforms for operators shall be so placed that operators can see the operation of their machinery at all times.

For leggings and shoes to be worn on pouring platforms, see Fig. 1, P. 256.

OPEN HEARTH DEPARTMENT

(a) When rebuilding a furnace, a tight plank fence shall be built on the charging floor, to prevent material falling on men working in the furnace ports.

(b) The hydraulic jib cranes shall be provided with a cable running over the sheave at the inner end of the boom, and attached to the floor at the base of the crane, to draw the runner back from over men working at the tapping hole.

(c) Provision shall be made so that when a furnace is down for repairs the gas cannot be turned into the furnace accidentally.

(d) Provision shall be made on hot metal cranes, so that no man can be confined in any crane cage, or in any other place from which it would be impossible for him to escape to a place of safety, in case hot metal should be spilled.

Ladles

(a) All ladle cars shall be equipped with some device for keeping ladles in an upright position.

(b) All ladles must be bottom heavy, so as to assume an upright position in case of breakage of any part of dumping mechanism.

Charging Cars

(a) Charging cars shall be equipped with guards over the truck wheels, covering both the front and sides of the wheels.

(b) Warning gongs shall be placed on all cars.

(c) All gears shall be encased, and a plate guard shall extend along both sides of the traversing carriage runway, of sufficient height (at least three inches) to prevent men placing their feet on the track.

(d) Bumpers shall be placed on each traversing carriage track, to prevent the carriage running back closer than two inches from the end plate.

ROLLING MILLS

(a) Subways or viaducts shall be provided where passageways across the mill are required. Subways shall be roofed with plate, to prevent scale from

Fig. 1. Footwalk on Outside of Open-Hearth Building, giving access to Crane Runway within. (American Steel and Wire Company.)*

Shortly after this walk was installed a ladle of hot metal was spilled, but the crane operator escaped without injury by means of the walk.

Fig. 2. Trial Installation of Cast-Iron Gear Shield for Roller Train. (National Tube Company.)*

The gears are entirely covered and run in oil, thus insuring first-class lubrication as well as thorough protection.

Fig. 3 shows an open-hearth charging machine with truck wheels guarded, gears enclosed, and a shield in front of the operator's seat. The crane hooks have safety handles, and the furnace is provided with water-cooled doors.

Asbestos mask and mittens worn by mason's helpers on hot furnace work, are also illustrated.

Fig. 3. Open-Hearth Equipment.†

* Subsidiary of the United States Steel Corporation.
† Courtesy of the American Steel Foundries Company.

Fig. 1. Shield at the Edge of a Bessemer Pouring Platform.*

This prevents the ingot moulds from being uncapped too soon. The gases which collect at the top of a mould may cause the metal to fly with explosive violence, if the cap is taken off while the steel is still molten. By the time a mould in this line has been pushed past the end of the shield, it has cooled sufficiently to prevent danger when the cap is removed.

Fig. 2. Automatic Couplers for Mould Cars.*

This coupler is extremely simple, having only two moving parts. The pin enters from the bottom and is held in position by the operating lever, which serves as a counterweight.

Fig. 3. Dummy Car for Use in an Ingot Train.*

Note arrangement of railings, toe-boards, grab-irons, etc. This car is equipped with two types of automatic couplers, for use with both broad- and narrow-gauge equipment.

Fig. 4. Grill-Work Protection over Ore, Coke, and Limestone Bins at Blast Furnaces.*

These guards prevent danger of men falling from car into bin with stock as it is being unloaded.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Safeguards at Rod Mill Rolls.*

Fig. 2. Screens in Front of Rod Mill Reels.*

Fig. 1 shows guard to prevent rods which are being rolled from jumping out of comb and injuring roller. The guard consists of two pieces, on one of which the rod is resting in the photograph. The overhanging portion is free to swing downward as a rod is pushed underneath it, but a counterweight returns it to the horizontal position, where it resists any upward movement of the rod. Note also hook back of operator, enclosure of rolls, and guard over trough, which offer additional protection.

Fig. 3. "Skull Cracker" Protection. †

Fig. 2 shows wire screens in front of rod mill reels, to prevent injury to reel-men in case a rod should "cobble" at the reel. These screens are made in sections, each section being hinged at the top so it can be swung upward and held by hook on horizontal shaft giving free access to the reel.

Fig. 3 shows equipment used for breaking heavy scrap. Note wall protection to stop flying pieces, also safety cage on ladder, and railed walks across the end of crane runway and on bridge-girders of crane.

Fig. 4 shows an oxygen helmet used for rescue or emergency work in gas-filled piping or compartments.

Fig. 4. Oxygen Helmet.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

† Courtesy Tennessee Coal, Iron and Railroad Company, subsidiary of United States Steel Corporation.

the tables falling into them. Table shafting which can be reached from subway or stairs shall be encased.

(b) Drive shafting on roller tables shall be covered with hinged plate covers over the top of shafts, and with hinged aprons at the side, or entirely encased.

(c) All coupling boxes, pinions and wabblers shall be guarded with shields.

(d) Leading spindles shall be fenced, if not otherwise guarded.

(e) Where passageways over spindles are required, viaducts shall be provided.

(f) Platforms shall be placed on roll and shear housings six feet or higher above the floor, with a ladder leading to same.

(g) Walks, running parallel with crane runways shall be placed on buildings, wherever practicable.

(h) Safety switches shall be installed in turntable pits, so that men going into the pit can cut off all power from the table.

(i) Bumpers shall be placed at the dead end of all roller tables, to prevent material over-riding the end of the table.

(j) A steel arm shall be placed at the outside ends of the skids of all loading beds, to prevent material from falling from the bed.

(k) Where practicable, scale tunnels under mills shall be arranged so that it will not be necessary for men to go under table when removing scale. This should be overcome by conveyors, or by making the pit on an incline, so that the scale will slide to one side."

Rod Mills

In addition to carrying out such of the provisions mentioned above, as are applicable, the following precautions should be taken in Rod Mills.

(a) In Belgian or looping mills the arrangement of combs should be such as to positively prevent danger of rods drawing up and injuring the catcher as he stands at the rolls. A good device for this purpose is shown in Fig. 1, Page 253.

(b) Suitable hooks should be placed in the floors, so as to catch loops as they are formed, and prevent their drawing up and injuring hookers or other persons walking across the floors.

(c) So far as practicable, the troughs or runs over which the looping rods travel should be floored over, or provided with overhanging curved guard plates to permit of men crossing them safely, and to prevent their being burned in case they should accidentally fall.

(d) Guards or screens should be placed at all points where a rod might "cobble" or jump from the guides and injure workmen. Such protection is especially needed for reel-men and conveyer-men at the finishing end of the mill. Wherever passageways are necessary, at points adjacent to the finishing passes, they should be thoroughly protected from flying rods. (See Fig. 2, P. 253.)

Screens for this purpose should preferably be made of heavy woven wire fabric and care should be taken to keep the mesh of such fineness that the smallest rod rolled cannot pass through it.

(e) Counterweights for furnace doors, gas valves, etc., should be suitably enclosed or guarded. (See Page 158.)

(f) Cranes, or trolleys with block and tackle, should be provided over roll trains, to facilitate safe handling of rolls when changes are being made.

(g) Some form of emergency power control should be provided for quickly shutting off the power in case of accident, such as an Automatic Engine Stop, Motor Stop, etc.

(h) A whistle or other suitable signalling device should be provided, so that signals can be readily transmitted from mills to engine rooms for starting and stopping, etc.

GAS PRODUCERS

(a) Provision shall be made so that when a producer is shut off from the main pipe, or when a soaking pit or a furnace is cut out, the gas cannot be turned on again accidentally.

(b) Cleaning doors on gas pipes opening on a platform or walk, shall be so constructed that they can be locked shut to prevent a back-pressure of gas forcing them open.

(c) All cleaning doors or explosion doors on gas pipes or mains shall be hinged. Where there are counterweights on explosion doors, they shall be provided with safety chains or other devices, to prevent the weight or door falling, should something break.

(d) Bar hole stoppers shall be put on with hinges."

CHAPTER 27

FOUNDRIES

SPLASHES of molten iron are the chief source of injury in foundries. Molten metal is particularly liable to lodge in the shoes of workmen if there is any opening through which it can penetrate. Even though the resulting burn is of itself insignificant, the injury may be chafed by the shoe and result in an infected wound of dangerous character.

CONGRESS SHOES

In an effort to avoid burns on the feet it has been made compulsory in some foundries for the men to wear Congress shoes which fit tightly about the ankles and have no openings for laces.

In order to encourage their workmen to wear such shoes, some concerns supply them at cost, or arrange for local stores to keep the shoes and furnish them to the workmen at a special price. The best grade of material should be used in the gore of Congress shoes; if the gore becomes permanently stretched it stands out from the ankle, forming a pocket into which hot metal may drop.

THE USE OF LEGGINGS, in addition to Congress shoes, practically eliminates all danger of such accidents. (See Fig. 1, P. 256.)

FLOORS

It is especially important that foundry room floors be kept in a clean and orderly condition, free from all unnecessary obstructions over which men carrying hot metal might trip. As far as possible, tools should be hung up or laid on shelves where they will not be in the way. Certain definite aisles should be laid out, and these aisles should be kept clear at all times.

FOR MEN WHO SAND-BLAST CASTINGS, helmets should be provided, to be used either with a fresh-air hose, or with a respirator, in order to avoid the inhalation of dust. (See Figs. 1 and 2, P. 257.) These men should preferably work in short shifts, the shifts "spelling" each other.

An exhaust system should be installed, a good arrangement being to have the castings placed on an open grill-work floor through which the sand falls. The dust should be drawn downward and out, as illustrated in the above-mentioned photographs, in order to minimize its diffusion.

GRINDING WHEELS

Where heavy castings are being snagged, a thorough enclosure of the wheel should be provided wherever possible. (Fig. 4, P. 257.) Wheels of safety shape, i.e., those having convex sides with concave flanges, may be used as an alternative where hoods are impracticable. Exhaust systems should be installed to carry away the dust. (For further details see "Abrasive Wheels.")

MISCELLANEOUS PROVISIONS

When a cupola is being lined, a cover should be placed over the opening at the charging floor, to prevent objects from falling down the cupola and injuring men below. (See Fig. 3, P. 257.) Tumblers for cleaning castings should be provided with guards. (Figs. 2 and 3, P. 257). Leather aprons and buckskin gloves are of value in protecting men who do snagging. (See Fig. 4, P. 257.) Canvas screens may be used to advantage to safeguard adjacent workmen or passers-by when chipping is being done. (See Fig. 1, P. 376.)

The use of chains and slings, the proper dressing of hammering tools, the protection of cranes and elevators, and the use of goggles are all important matters in Foundries. For discussions of these subjects, see Chapters 25, 21, 18, 19, and 48.

Fig. 1. Standard Foundryman's Legging and Shoe. (Courtesy National Founders' Association.)

The legging and Congress shoe shown in Fig. 1 have been adopted as standard by the National Founders' Association. This legging is made of canvas. It is held in position by spring clips, which enable the workmen to quickly put on or remove the legging. A flap attached to one side overlaps the other side, forming a complete and tight-fitting enclosure.

Where approved shoes and leggings are worn as illustrated in the photograph, burns of feet and ankles, which may prove so troublesome in foundries, are eliminated.

The guards shown in Figs. 2 and 3 prevent danger of the operator being caught on projecting bolts or fastenings of the tumbler. When the tumbler is being filled or emptied, the guard can be instantly thrown back out of the way.

Note notches in bar on which belt-shifter slides (Fig. 2). These notches hold the shifter securely and prevent danger of the belt creeping and starting the machine unexpectedly.

Fig. 2. Tumbler Guards, raised and lowered.*

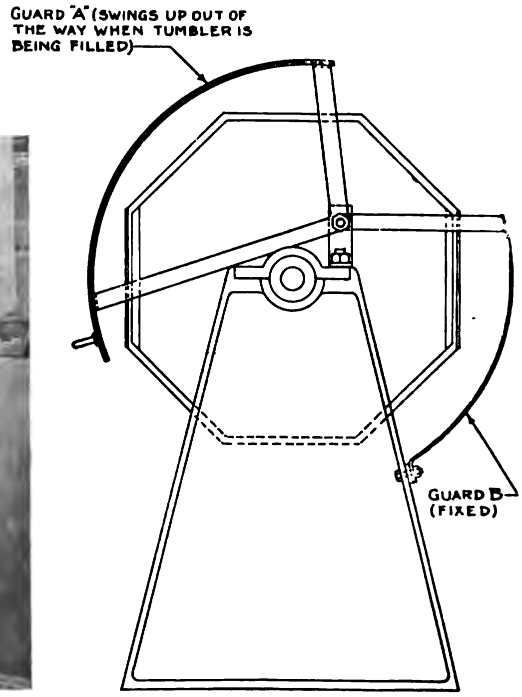


Fig. 3. Tumbler Guards.*

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Sand-Blast Arrangement for Cleaning Castings. (General Electric Company.)

Fig. 2. Sand-Blast Operator. (American Steel Foundries Company.)

In Fig. 1 the sand-blast operator has a helmet, inside of which a respirator is worn.

In Fig. 2 an operator is shown with respirator, goggles, leggings, and helmet having an air connection.

Note exhaust connections in both pictures to carry the dust down and out of the room, thus keeping the air clear.

Fig. 3. Guard for Cupola during re-lining.*

Fig. 4. Department for Snagging Castings. (American Steel Foundries Company.)

The cupola cover shown in Fig. 3 prevented a serious accident shortly after it was placed in service.

Fig. 4 shows belt guards, hoods and safety flanges for abrasive wheels, and steel-studded apron provided for men doing heavy grinding.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

CHAPTER 28

WIRE MILL EQUIPMENT

WIRE DRAWING DEPARTMENT

WIRE drawing is a relatively hazardous occupation, particularly where the coarser sizes are being drawn. There is danger of the operator being caught in the machinery and he is also exposed to cuts and scratches from the wire. Even slight injuries of this sort may become infected and cause serious trouble, if neglected.

The principal ways in which accidents occur in wire mills (coarse drawing) are as follows:

I. The operator may be caught on the revolving block and carried around it. This may happen from clothing catching on some projection on the block; the hand-leather which wire drawers usually wear may be caught on a projection, or between the block and the wire at the point where they run in contact, or fingers may be caught at this point. The latter form of accident usually occurs from the practice, common among wire drawers, of feeling the wire between the die and the block to see if it is running "smooth."

II. The wire may fail to run from the reel properly and drag the reel up to the bench catching the operator and crushing him between the reel and bench.

III. The wire may run too freely from the reel, or spring over top of it, causing a snarl or tangle. In trying to straighten out this snarl the operator may have his hand or foot caught in one of the loops, and this, being drawn tight at the die, may amputate or seriously lacerate the member.

IV. The wire drawer may be struck by a flying end of wire; either the last end of the piece or an end formed by the wire breaking in the die. Where hard stock is being drawn there is a tendency for the last end to spring upward, and as the operator goes to the treadle to shut down the block this end may strike him in the eye, face, or other parts of the body, causing a bad puncture wound; this has even been the cause of a fatal accident.

V. Wire may accidentally catch under the flange of the block and be wound around the spindle, thus making the clutch inoperative. If the wire drawer attempts to remove this tangled wire while the block is running, there is considerable danger that it will catch his hand (or tool) and draw it around the spindle.

VI. Where wire drawing blocks are equipped with the ordinary grab-clutch, controlled by a foot treadle, accidents sometimes occur from the treadle being improperly locked when the block is shut down, so that it rests on the edge of the treadle-catch in veritable hair-trigger fashion. In working around the block the operator may accidentally touch the treadle with his foot, or the jarring of the machinery may cause it to drop out of the catch and start the block. The unexpected starting of the block in this way is very likely to entangle the operator and cause an accident, particularly if it occurs while the block is being stripped.

VII. Where the blocks are constructed with an open space inside, there is a tendency for wire drawers to use this space for storage. Injuries are liable to occur while the men are placing objects in the blocks or removing them.

VIII. In addition to the above, which constitute the special hazards of this industry, there is also exposure to gearing, particularly when oiling is being done, and danger from upsetting trucks, etc., as mentioned later.

Cause I. Operator Caught on Block

In order to guard against accidents from Cause I, several precautions are necessary. The construction of the block should be smooth and as free as possible from projections which might catch in clothing. The pins should have a safety top of some sort, preferably a circular loop turned over horizontally. If a vice is used to hold the wire, it should be operated by a handwheel in preference to a crank. (See Page 261.)

Hand-leathers are preferable to gloves, and should be of safety type, — that is, instead of having a solid strap across the back a spring should be used, so that if the hand-leather is caught in the machinery the spring will release and thus free the hand. In order to prevent rubbing and irritation of the skin, the spring should be enclosed in some sort of guard; for this purpose leather tubing gives good results. (See Fig. 2, P. 263.)

The practice of feeling the wire between die and block should be prohibited, or discouraged as much as possible. The use of loose clothing which might catch between the wire and block should not be permitted.

While the above-mentioned precautions minimize the danger of the operator being caught on the block, such accidents are almost certain to occur occasionally. In order to prevent serious results the block must be shut down instantly when a man is caught.

This may be accomplished by having a lever or rope beside the block, arranged so that, if struck, it will stop the block automatically by throwing out the clutch, or by shutting down the motor if the frame is motor driven. In order to make this type of stop quickly effective, a counterweight may be used to operate the treadle, this counterweight being released by a latch or trigger to which the lever or rope is attached. The latter should be spaced not more than seven or eight inches from the side of the block, so that any one drawn around the block would be certain to strike it and operate the stop. (See Page 261.)

Where this device has been used, it has operated so effectively that in a number of cases a man caught on the block was either saved from injury entirely, or the injury which resulted was so slight as to be insignificant. Without the device such accidents have caused fatal injuries.

With this combination, accidents from Cause I should be practically eliminated. It is well, however, as an additional precaution, to keep the frame around the block as free as possible from projections against which a man might strike if drawn around the block.

Cause II. Reel Drawing up

In order to prevent accidents from Cause II the reel may be connected to the automatic block stop already described, or it may have a direct connection to the treadle in such a manner that if it is drawn forward the block will be shut down automatically.

Cause III. Wire Tangling as it comes from Reel

Probably the simplest and best way to prevent accidents from this source is to have the wire as it runs from the reel pass through an eye (some six or seven inches in diameter) on the end of a lever which will stop the block automatically if it is drawn forward. This tends to straighten out any tangles and cause the wire to run through smoothly. If a serious tangle occurs the block is stopped without danger to the operator, and the wire can then be straightened out.

This type of accident is closely related to that described in Cause II, and if the eye through which the wire runs is placed in a floor-lever located some six or eight feet back from the frame, this one provision may safeguard both sources of hazard. (See Fig. 1, P. 261 and P. 263.) If, however, the eye is close to the die, or attached to it as is the case in some wire drawing frames, an additional precaution is needed to take care of Cause II.

Cause IV. Flying Ends of Wire

To guard against accidents from Cause IV, it is necessary to furnish the operator with some means for shutting down the block at a distance, where he will be out of reach of the flying end, or to have the machinery arranged so that it will shut down automatically when the wire breaks or the last end runs through the die.

The floor-lever mentioned above may be used for this purpose, the operator merely pushing it forward when he wishes to stop the block. Patented drawing frames may be obtained, arranged so that a slight movement of the die, which occurs when a wire breaks or runs out, is utilized to trip the clutch-operating mechanism and thus stop the block. Either of these arrangements is satisfactory, as they both eliminate the necessity for the wire drawer going to the operating treadle while the block is still running and the end whipping around it.

Cause V. Wire Wound Around the Spindle

Danger from this source may be avoided almost entirely by the use of a rim or skirt extending downward from the flange of the block. A second rim, within which the first one runs, should be permanently attached to the top of the frame. This gives an interlocking arrangement, making it practically impossible for wire to pass underneath the flange of the block and wrap around the spindle. (See Fig. 4, P. 263.)

A rule should also be enforced forbidding the wire drawers from trying to remove the wire while the machinery is running, in case it should become wrapped around the spindle through any mischance. The only safe way is to leave the wire in such cases until the frame can be shut down; it can then be removed without danger.

Cause VI. Treadle Slipping out of Latch

Where a block is driven by a friction clutch there is little danger of its starting unexpectedly. With the ordinary treadle-operated grab-clutch, however, there is considerable danger that accidents will occur from the treadle not being properly latched.

A spring should be attached to the treadle so as to draw it underneath the catch. In order to further facilitate proper latching of the treadle, it is well to have the bottom of the opening in the treadle-plate shaped so that the downward pressure of the operator's foot will naturally throw the treadle underneath the catch.

The treadle-catch should be constructed in such a way that when the treadle is properly placed it cannot be jarred from position. This may be accomplished by a toothed or locking construction.

Cause VII. Space in Blocks used for Storage

This can be avoided by casting the blocks with solid tops, or by placing covers on blocks which are of open construction. Ventilating slits or openings (not over $\frac{1}{2}''$ wide) should be left in the top or cover, to facilitate the radiation of heat.

Gearing

The large bevel gears commonly used to drive the individual blocks are a source of hazard, and should be so enclosed or boxed in as to prevent danger of accidental contact with them. (See Fig. 1, P. 261).

Oiling

The problem of satisfactorily lubricating wire drawing equipment is a difficult one on account of the flying dust, more or less of which is inevitable in this industry. This means that in order to maintain proper lubrication it is usually necessary to oil the machinery while it is running.

Safe facilities should be provided for the use of the oiler. In some cases these have been furnished by installing extension pipes which lead from the bearings to points where they can be easily reached. (See Fig. 4, P. 169.)

Trolleys

Safety conditions are improved by having trolleys over rod frames, for removing and replacing blocks. Without them fingers or other members are liable to be crushed in attempting to handle these heavy parts.

Reels should be free from bolts or other projections on which hand-leathers or clothing might catch. Serious accidents have resulted from failure to observe this precaution.

Trucks

Serious accidents may be caused from a wheel coming off a heavily loaded truck and permit-

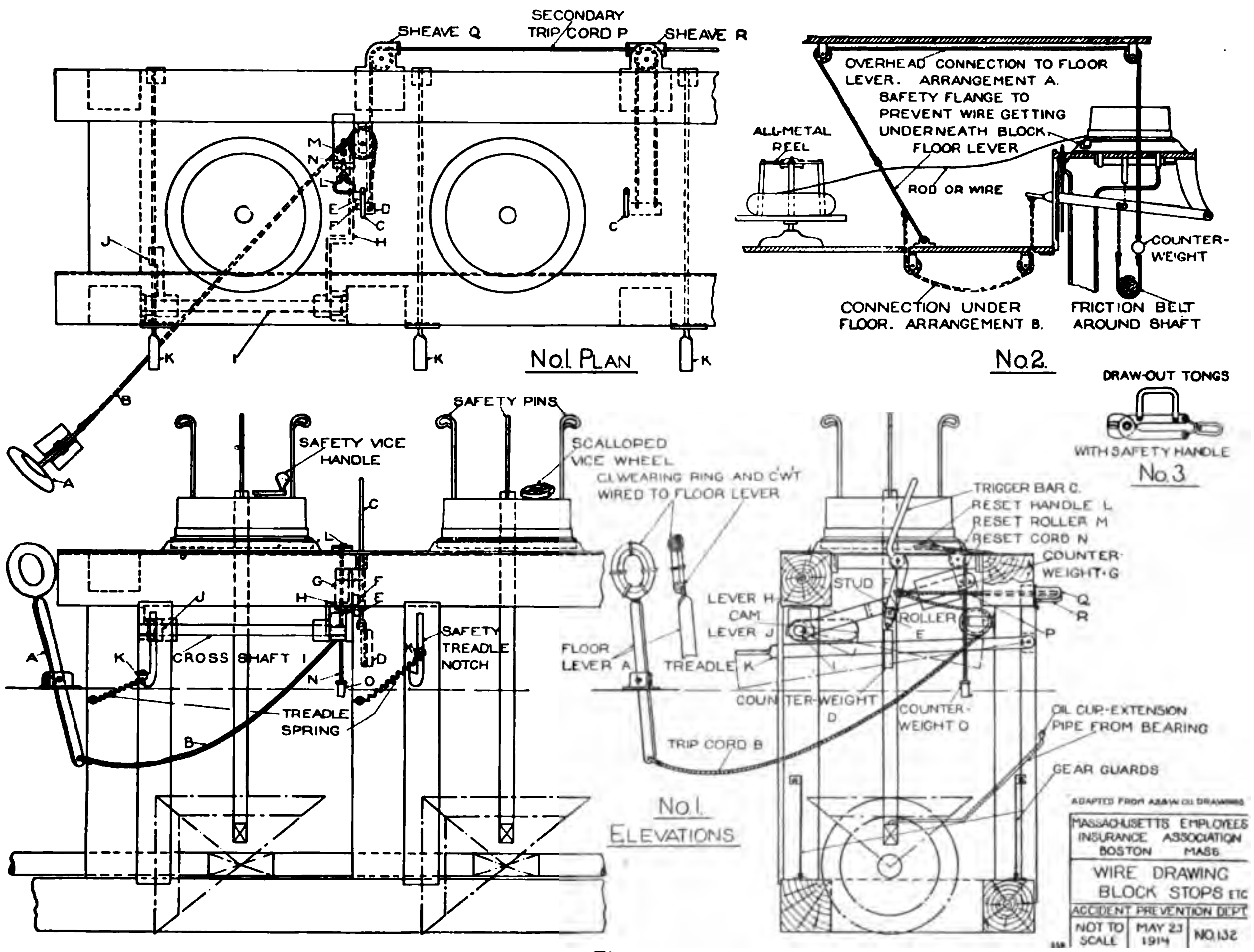


Fig. 1.

This drawing illustrates several types of " automatic stops " for wire drawing frames. In No. 1, trigger-bar C supports counterweight G by means of roller E underneath triangular stud F on side of lever H. When trigger C is thrown in either direction, counterweight G is thus released, pulling down lever H, which is keyed to shaft I; cam-lever J, which rests on treadle, being also keyed to shaft I, is thus rotated downwards, depressing treadle and stopping block. Counterweight G is re-set by pulling up cord N (which passes over roller M), by means of handle L. Cord N passes through an eye in end of lever H.

Counterweight D holds trigger C in vertical position, so it re-sets automatically when lever H is raised.

Trigger C will also be tripped by cord B if floor lever A is drawn forward.

If a man is caught on the drawing block, his body will strike trigger-bar C and thus instantly stop the block. Secondary trip cord P, passing around sheaves Q and R, pulls trigger of adjacent block on right, thus stopping that block, also.

If the wire should tangle and draw up the reel, the stop would be operated by floor lever A. Arrangement B in No. 2 shows a direct connection from the floor lever to the treadle. Where the operating treadle is on the right-hand side of the block, arrangement A is satisfactory.

Note also handle for draw-out tongs, safety pins, safety vice handle and vice wheel, safety flange on block, gear guards, extension oil cup, etc.

ting it to upset, — thus catching some one underneath a load of wire. Such accidents are likely to occur, from wear or breakage, where a light pin is used to secure the truck wheel on the axle. Such pins should be approximately $\frac{3}{8}''$ in diameter, and the use of a "safety washer" is recommended. By this is meant a washer which is secured to the axle by the pin, so that the wear of the wheel comes on the washer and not on the pin, — the washer being thick enough to make ample provision for wear. (See Figs. 3 and 4, P. 264.)

Where trucks are of two-wheeled, or "wheelbarrow" type, knuckle-guards may be used advantageously to protect the hands of men wheeling the trucks, from contact with doors, posts, or other objects, in passing. (See Page 264.)

Exhaust Systems

Wire drawing may be classed as one of the dusty trades, and exhaust systems should be provided to minimize danger from this source.

Fine Wire Drawing

The foregoing discussion applies particularly to equipment used in drawing the coarser sizes of wire from rods (usually done on blocks 22″ or more in diameter). As the finer sizes are reached, such as are generally drawn on blocks 16″ in diameter, the hazard is diminished to some extent, particularly from flying ends (Cause IV). There is little danger from this source on these sizes, although the other causes discussed above are applicable to 16″ frames used in ordinary wire drawing.

For the small blocks, usually about 8″ in diameter, used in drawing fine wire ("mattress wire," "broom wire," etc.), the danger from the various Causes I to VII is practically reduced to the vanishing point. Gearing, belts, etc., should be properly enclosed and some means should be provided for quickly shutting down the frame in case of emergency.

This may take the form of a motor stop or a friction clutch, with an operating cord extending lengthwise over the frame within easy reach of the operator. If a grab-clutch is used, a counterweight may be needed to throw it positively out of engagement, but this counterweight may be released by a trip from the cord over the frame. A similar device can be used for shifting the belt, where the frame is belt-driven.

The provision of some form of individual power disconnecting-device for each fine wire frame is very desirable. There is danger of persons being caught on the spindles, particularly when a block is removed for any purpose. Spindles without blocks should not be permitted to run without a guard or enclosure over the projecting end.

CLEANING HOUSE

The principal hazard in cleaning houses is that of acid burns, and an arrangement should be provided which will make it unnecessary to carry acid by hand. The following system has been used very successfully for this purpose:—

Acid is received in tank cars, from which it is discharged by gravity to an underground storage tank. From this it is forced by compressed air to an overhead supply tank, in the cleaning house, merely large enough to hold a few hours' supply of acid. From the supply tank acid flows by gravity to small receiving boxes, graduated so that the acid can be measured. These receiving boxes are slightly elevated above the cleaning tubs, to which the acid flows by gravity after it has been properly measured. (See Fig. 3, P. 263.)

The floor around cleaning tubs should be of slatted construction, with drains underneath to carry off overflow, splashings, drippings, etc. It should be carefully fitted around the tubs and constantly kept in good repair, so as to minimize danger of persons tripping and falling into the tubs.

The tops of the latter should be elevated some three feet above the surrounding floor, so as to reduce this danger, which is especially great in winter when steam from the tubs tends to fill the room and make everything obscure. This condition can be improved somewhat by providing a heating and ventilating system for the cleaning house, but it cannot be eliminated completely.

The chains or cables used on cranes for

Fig. 1. Automatic Stops for Drawing Blocks.*

Fig. 2. Safety Hand-Leather.*

Fig. 1 shows safety stop with overhead connection to floor lever.

Pendent push-buttons over the frame operate the automatic engine stop system.

The hand-leather, Fig. 2, is held in position by a spring inside a leather tube. In case this hand-leather is caught in the machinery, the spring stretches, releasing the hand.

Fig. 3. Safety Acid Handling System in Wire Mill Cleaning House.*

Fig. 4. Protection Flanges for Wire Drawing Blocks.*

Acid flows from overhead tank to the boxes shown in Fig. 3, is measured, and then flows by gravity to the cleaning tubs. It is not carried by hand at any point.

The flange on block shown in Fig. 4 interlocks with a second flange on the frame, and prevents wire from getting underneath the block.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Automatic Stop for Galvanizing Take-up Frames.*

Fig. 2.

This device consists of a small shaft (A) located back of the blocks, a yoke on this shaft being connected by cords (B) to the motor switch. Horizontal rods (C) are fixed to shaft (A) and project outward between the take-up blocks.

If a man should be caught and carried around a block his body would strike one of these horizontal rods, rotating shaft (A), thus pulling out the motor switch and stopping the motor.

The shaft is extended so that the furnace-tender (with foot resting on it in Fig. 2) can operate the stop. Note ventilating outlet above furnace-tender.

Fig. 3. Knuckle Guards and Safety Washers for Trucks.*

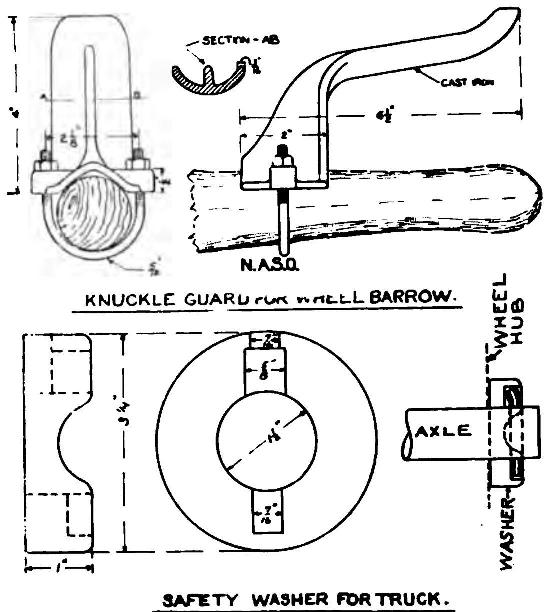


Fig. 4.

Where a truck-wheel bears directly against the pin that secures it to the axle, the pin soon wears through. This may result in the wheel coming off and the truck upsetting.

The safety-washer shown above is fixed to the axle, so that the wear comes on the washer and not on the pin. This washer is large enough to wear indefinitely without being dangerously weakened.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

filling and emptying the tubs should be inspected at regular intervals and renewed before their strength is dangerously impaired. In addition to the wear and tear of ordinary service, they are attacked more or less by acid.

The acid fumes make it difficult to keep a cleaning-house crane properly lubricated, thus requiring more than usual attention to maintain the crane in good condition. Safe means for applying lubrication to overhead bearings (preferably consisting of stairways or fixed ladders and permanent platforms), should be provided.

GALVANIZING DEPARTMENT

There is some hazard from the use of acid in galvanizing departments, and a mechanical handling system, as mentioned for cleaning house, should also be installed here. Hoods should be placed over the acid tanks for the removal of fumes, which can generally be satisfactorily accomplished by means of natural draught.

Accidents are liable to occur at the take-up frame, from men being caught on the revolving blocks. Means should be provided for instantly shutting off the power and stopping the entire frame when an emergency of this kind arises. In order to be effective, such a device should be arranged so that if a man is caught his body will operate the safety device and automatically stop the frame. (See Figs. 1 and 2, P. 264.)

The individual blocks should be equipped with clutches by means of which they can be shut down separately. These clutches should be kept in operating condition at all times.

A signalling system should be installed, so that men at the take-up frame can be warned immediately of trouble at the reels. This system should preferably be of electric push-button and annunciator type.

Unless a rule can be enforced forbidding men from getting up on lead or spelter furnaces while they are in operation, they should be railed or screened so as to prevent any one from falling into the molten metal.

Where the space under hot wires is used as a passage-way, a guard should be placed underneath the wires to prevent their falling and injuring some one. Railings should be erected at any points not thus protected, to prevent their being used for passage.

CHAPTER 29

RAILROAD EQUIPMENT

Adequate steps, ladders, hand-holds, running boards, railings, etc., should be provided for all rolling stock. Such provisions are now covered by national standards formulated by the Interstate Commerce Commission. Full information on these standards may be obtained upon application to the Commission at Washington, D.C.

The following general safety provision for railroad equipment have been prepared with the requirements of industrial plants particularly in mind. Many of the provisions, however, are applicable to any railroad system.

LOCOMOTIVES. Where the rear of locomotive cabs is enclosed, as is sometimes done in those used for yard switching service, it is important to have ample windows extending clear across the cab, so the engineer will have an unimpeded view of the track when the engine is running backward. Serious accidents have occurred from the inability of the engineer to see persons near-by on the track under these conditions.

Gage glasses and sight-feed lubricators should be arranged so that there is no danger of the glass breaking and causing injuries. This may be accomplished by the use of heavy glass (such as is contained in the "bulls-eye" type of indicator), or by installing guards of wired glass, etc. (See Page 89.)

The standards prepared by the Committee of Safety of the U.S. Steel Corporation for various kinds of railroad equipment are given below: —

CARS

All cars on narrow-gauge or broad-gauge tracks shall be provided with either automatic M.C.B. standard, or automatic link and pin, couplings. (See Fig. 2, Page 252.)

All special railroad cars for skelp steel, open hearth charging boxes, etc., shall be provided with suitable side stakes or end stakes.

(In loading material on cars, care should be taken to see that no portion of it will project over the sides, or fall off in transit. Large or heavy pieces should be braced to prevent shifting.)

TRACKS, ETC.

All important railroad crossings shall be provided with swinging railroad gates, with light on same at night where necessary. (See Fig. 2, Page 267.)

All dead-end tracks shall be provided with approved bumping blocks.*

All very dangerous places shall be provided with (fences or with) overhead bridges or subways, to keep men off the tracks entirely. (See Page 15.)

All frogs, switches, and guard-rails shall be blocked. (See Figs. 2 and 3, Page 267.)

When new switch stands are installed they shall be constructed so that the lever will be thrown parallel with the rails.

The design and application of all safety devices shall be in strict accordance with the National and State Railway Safety Appliance Laws.

TRESTLES

Trestles shall be equipped with walks, the outer edge of which shall be at least six feet from the rail. Where practicable, the floor of this walk shall extend to within four inches of the ends of the ties. Each walk shall be equipped with a substantial metal railing and toe-board. (See Fig. 1, Page 270.)

On trestles over pig-iron yards, and at other places where material is unloaded from side of cars, footwalk may be placed at a distance, and part of floor of walk may be arranged so that it can be lifted to allow metal or other material to fall through.

Where there is a driveway or passageway under a trestle, it shall be completely planked over at that point, between the rails and between the tracks.

Bents or trestle supports shall be enclosed, forming division walls to keep pig-iron (or other materials) from tangling around legs of open bents supporting trestle. Division walls are not advocated except at trestle supports.

TRACK CLEARANCES

The provision of adequate clearance between railroad tracks and structures over the tracks, or between tracks and poles, stock piles, etc.,

* A properly arranged gravel pile may serve to stop a car, but may injure the trucks; bumping blocks are accordingly preferable.

Fig. 1. Grill-Work Protection for Bins, Hoppers, etc.

Fig. 1 shows a protective grating for hopper under railroad track, into which cars of coal are unloaded. A man was caught in the coal as it ran out of a car, and suffocated in this pit before the grating was installed. Adequate provision should be made to guard against such accidents where materials of this sort are handled. Such gratings can be advantageously constructed of flat bars and channel sections, riveted together.

Accidents resulting from men getting their feet caught in frogs, switches, and guard-rails are of relatively frequent occurrence. A good form of protection is shown in Figs. 2 and 3.

In Fig. 2, the space underneath the head of the rails is filled, leaving only a "V"-shaped opening in which a foot cannot catch. The filler should preferably be made of a rolled steel section, but hard-wood blocks answer the purpose if kept in good repair.

A safety gate will be noted in the background of Fig. 2. This gate is placed at a crossing in such a way that it bars either track when the other is in use. The gate is painted white, so it is readily discernible in the daytime, and a lantern is hung on it at night.

Fig. 2. Guards for Switch Points.*

Fig. 3. Cast-Iron Blocks for Guard-Rails, Frogs. etc.*

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

FOUR TRACK POLES											
Length*	Dimensions of Sections								N T Co Call No	Weight in Lbs	Max Side Pull**
	Diam A	Length	Diam B	Length	Diam C	Length	Diam D	Length			
34-0	7625	17-8	6625	10-10	5563	8-6			8782	892 1	1275
35-0	8625	18-0	7625	11-0	6625	9-0			8813	932.1	1360
36-0	8625	18-6	7625	11-6	6625	9-0			8853	957.8	1310
37-0	8625	19-0	7625	11-6	6625	9-6			8893	981.2	1265
38-0	8625	19-6	7625	12-0	6625	9-6			8933	1007.0	1220
39-0	8625	19-6	7625	12-6	6625	10-0			8973	1028.0	1185
40-0	8625	20-0	7625	13-0	6625	10-0			9023	1350.1	1465
41-0	8625	20-0	7625	11-0	6625	8-6	5563	6-0	9459	1302.5	1390
42-0	8625	20-0	7625	11-6	6625	8-6	5563	6-6	9462	1361.4	1320
43-0	8625	20-0	7625	12-0	6625	9-0	5563	6-6	9461	1402.5	1260

SINGLE TRACK POLES											
Length*	Dimensions of Sections								N T Co Call No	Weight in Lbs	Max Side Pull**
	Diam A	Length	Diam B	Length	Diam C	Length	Diam D	Length			
34-0	5563	17-8	4500	10-10	3500	8-6			8780	585 8	482
35-0	5563	18-0	4500	11-0	3500	9-0			8830	602 2	600
36-0	6625	18-6	5563	11-6	4500	9-0			8851	609 8	680
37-0	6625	19-0	5563	11-6	4500	9-6			8891	624 6	640
38-0	6625	19-6	5563	12-0	4500	9-6			8931	641 2	620
39-0	6625	19-6	5563	12-6	4500	10-0			8971	653 8	600
40-0	6625	20-0	5563	13-0	4500	10-0			9011	670 4	580
41-0	6625	20-0	5563	11-0	4500	8-6	3500	6-0	9458	670 6	560
42-0	6625	20-0	5563	11-6	4500	8-6	3500	6-6	4661	681 5	540
43-0	6625	20-0	5563	12-0	4500	9-0	3500	6-6	9460	694 2	530

* This is over-all dimension less allowance for joints of 18" per joint

** This is maximum estimated load pole will carry when planted 6 ft in ground and loaded 18" below top calculation based on fibre stress of 22000 lbs per sq. inch

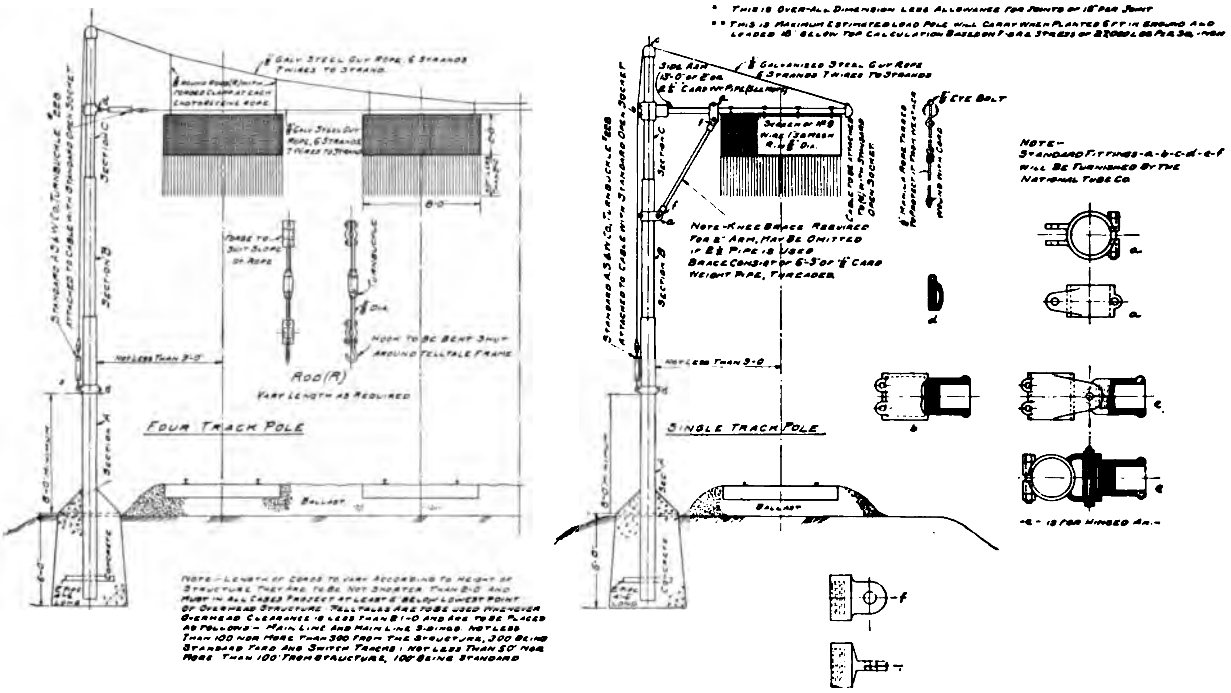


Fig. 1. Railroad Tell-Tale, for Warning Men on Top of Cars against Overhead Obstructions.*

The construction shown in Fig. 1 practically eliminates danger of "danglers" tangling, and thus becoming inoperative.

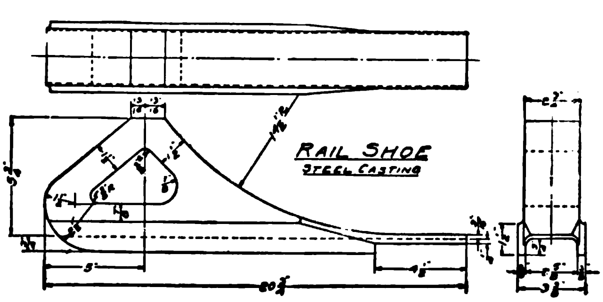


Fig. 2. Rail Shoe, or "Skidder." *

This shoe, when placed on a railroad track, will slide the wheels of a car striking it, and quickly stop the car.

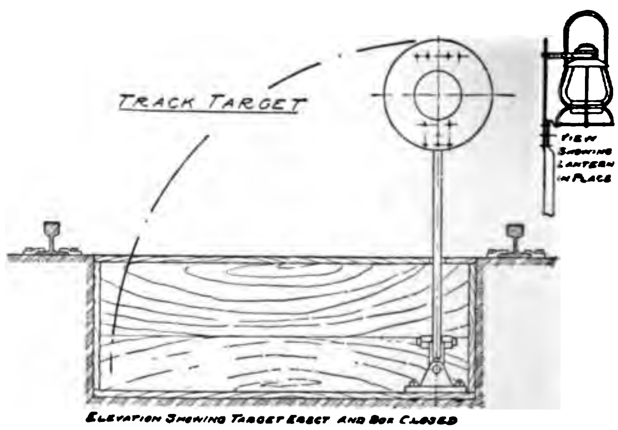


Fig. 3. Folding Track Target.*

This target is of value at warehouse tracks, etc., to prevent cars being shifted while men are working in them.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

Fig. 1. Safeguards for Locomotives.

Fig. 2. Standard Tell-Tale. (American Steel and Wire Company.)*

Fig. 3. Double Derailing Track Target. (National Tube Company.)*

Fig. 1 shows safety railings, steps, hand-holds, etc., for locomotives. The head-light can be turned, as shown at the left of this picture, and cleaned from the walk. Note also "Keep Off" sign at footboard.

Fig. 2 shows standard railroad tell-tale. (See Page 268.)

Fig. 3 illustrates a derailing track target; this can be placed on either rail, and affords protection from both directions.

Switch-levers should be arranged to throw parallel with the track. Where thrown at right angle with it, as shown in Fig. 4, the danger of a man falling and being struck by the locomotive is apparent. Fatal accidents have thus been caused to trainmen running ahead of a locomotive to throw a switch.

Fig. 4. Dangerous Switch Arrangement.

* Subsidiary of United States Steel Corporation.

Fig. 1. Footwalks on Coal Trestle.*

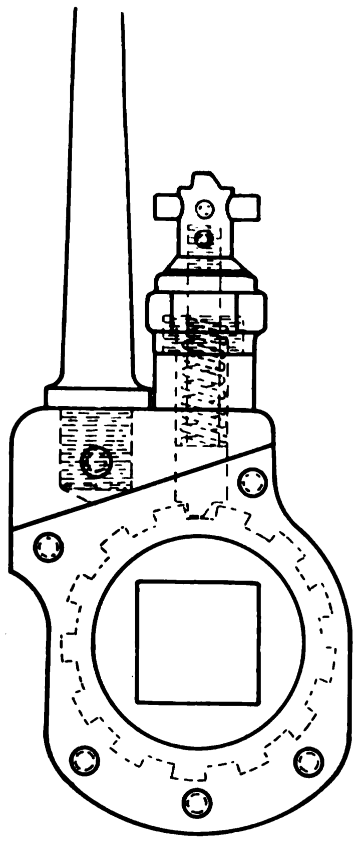


Fig. 2. Fig. 3.
Car Wrench. (Pat.)

Considerable hazard is attached to unloading cars of coal, etc., on elevated trestles. Workmen are liable to fall from the trestle in reaching cars or in passing from one car to another. Where hopper-cars are handled, there is danger of the wrench used to release the bottom doors being jerked from a man's hand and striking him or throwing him from the trestle.

These hazards can be reduced by providing suitable walks, equipped with standard railings and toe-boards, as illustrated in Fig. 1.

Danger in opening doors may be practically eliminated by the use of a suitable wrench, such as illustrated in Figs. 2 and 3. This wrench works in either direction, and is offset to protect a man's knuckles from contact with side of car; it can be held rigidly in position, and the door allowed to drop by releasing the catch shown in Fig. 2.

One of the men in the photograph (Fig. 1) is using a wrench to open the door, and the other is holding a car-mover for "pinching" cars along the trestle to any desired position.

The latter is a form of safety device, as injuries sometimes occur from the use of make-shift car-movers. A disc may be placed on the handle of a car-mover or crowbar, to prevent danger of knuckles striking the rail.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

beside the tracks, is most important. Many accidents occur through the lack of such clearances. In laying out new work it is strongly recommended that the standards given below be adhered to, and that equipment already in place be arranged to conform, wherever practicable, to these standards.

A. **Broad gage track,** — minimum clearance to structure or material pile.

1. *Side Clearances:*
   (*a*) 7′ 0″ from centre line of track to loading or unloading dock, walls of depressed track and wheelbarrow platforms, etc.
   (*b*) 7′ 4½″ from centre line of track in all stock yards.
   (*c*) 8′ 6″ from centre line of track wherever not otherwise specially provided.
2. *Overhead Clearance:*
   (*a*) 21′ 6″ from top of rail to any structure.
   (*b*) 25′ from top of rail to any wire.

B. **Narrow gage track,** — minimum clearance to structure or material pile.

1. *Side clearance* at all places to be not less than 18″, from side of widest car used, to piled material.
2. *Overhead clearance* to be governed by local conditions, but must be not less than 7′, measured from highest point on car where a man might stand.

C. **Track Clearances:**

(*a*) 13′ from centre line of one broad gage track to centre line of adjoining broad gage track.
(*b*) The distance between narrow gage tracks, or between a broad and narrow gage track, to be such as will insure a minimum clearance of 2′ 6″ between widest cars used.

All clearances, "A," "B," and "C," are based upon tangent measurements. Where track is on a curve, allowance should be made for overhang of cars on the curve, so as to maintain for all uses of the track a clearance equivalent to that required for a straight track.

Where it is impracticable to secure standard side clearances mentioned under A-1, warning signs should be posted reading approximately as follows: "Warning! Will not clear man on side of car." Where overhead clearance (2-*a*) is less than 20′ from top of rail to structure, standard tell-tales should be placed over the track at each side of the structure. For data as to construction and arrangement of tell-tales, etc., see page 268. (Side clearance tell-tales have been used also, and are recommended in addition to the warning sign, wherever practicable.)

"DON'TS"

For the Guidance and Benefit of Railroad Employees*

"In all cases of doubt *Take The Safe Course.*"

Enginemen and Fellow Employees

Don't move engines or trains until after ringing the engine bell.

Don't move engines or trains when no one is in sight to give signals.

Don't move your engine until you know where your fireman is. He may be underneath the engine.

Don't pile coal high on your tender; it is dangerous as well as wasteful.

Don't start down grade unless you are sure the air-brakes on your engine (both straight and automatic) are in good working order, and train under full control.

Don't use emergency air-brakes unnecessarily, or otherwise use your air too severely. You may jerk men off cars, or lock wheels and skid.

Don't fail to blow short blast of whistle when making emergency stop, as a warning to trainmen.

Don't move away from a water-plug until after fireman has swung spout back in proper position. You may jerk him off tender.

Don't leave your engine in charge of a "green" fireman.

Don't visit with your fireman or any one else in cab while engine is in motion; it is bad practice, — you might take your eye off the work at the critical moment and cause a serious accident.

Don't leave your engine at any time without first opening the cylinder cocks and placing reverse lever in central position on quadrant.

Don't neglect to have a supply of sand at all times.

* Issued by the Lake Terminal Railroad Co., subsidiary of the U.S. Steel Corporation.

Fig. 1.*

Adjusting couplings by hand or foot as the cars come together is an unsafe practice, and one which should not be permitted.

Fig. 2.*

Many persons are injured while climbing between cars. Better wait until they are moved, or else walk around.

Fig. 3.*

Do not ride on footboard of engine when shoving cars. A number of men have thus been killed when hard couplings pushed the drawheads in.

Fig. 4.*

Never attempt to walk between cars temporarily uncoupled and standing close together. A sudden movement of the cars may cost you your life.

* From safety bulletin of the New York Central Lines, and reproduced by their courtesy.

Trainmen and Fellow Employees

Don't ride on side of any cars after night until you are thoroughly familiar with the yard.

Don't ride on top or sides of any cars when switching in or around buildings or structures, or on ladder tracks, unless you know there is sufficient clearance.

Don't get on footboards of approaching engines while standing between the rails.

Don't ride in gangway of engine, between cab and tender, or on footboard between engine and cars that are being shoved.

Don't ride on loaded hot metal or cinder ladle cars, or on cars loaded with hot skelp.

Don't give signals for moving train until you know you are right.

Don't leave switches unlocked where locks are provided.

Don't leave car replacers lying around after replacing a car or engine, — put them back where they belong.

Don't switch cars or place them on tracks protected by danger targets.

Don't couple onto cars with overhanging loads.

Don't go between cars to uncouple.

Don't go between cars to cut them when operating lever or chain is disconnected, — use lever on adjoining car, and set out defective car and report it to Yard Office at once.

Don't ride on top of cars of rails or pipe when shifting.

Don't sit on brake wheel or stand near end of moving car.

Don't use your foot to shove draw-bar over.

Don't reach over the draw-bars to turn the angle cock when coupling up air.

Don't haul cars behind engine going up grade, nor push cars ahead of engine going down grade. Always keep locomotive below train.

Don't fail to have not less than five (5) cars of air in working order coupled up next to the engine when hauling trains to and from the yards of the connecting railroads, and the air coupled up in all cars when making deliveries to the Boiler House Trestles.

Don't fail to be in a position to assist engineer to stop trains on grades.

Don't switch cars that are improperly loaded, — report same at once to the Yard Office by telephone or in person.

Don't go between or under cars to make "emergency repairs" such as chaining up couplers, etc., until after notifying engineer and having engine cut off and moved away from train, as well as having trainman to protect the other end of train. Engineer must not couple up engine again until notified by the same party that it is safe to do so.

Don't fail to set brakes and block wheels of cars left standing on grades.

Don't operate cars at night without proper lights.

Don't leave material or rubbish lying close to tracks where some one may stumble over it and fall under a train.

All Employees

Don't fail to instruct new men as to their duties.

Don't fail to ask for information if you do not understand.

Don't take a chance where there is a question of safety concerned, it may mean death to some one. Be sure you are right and then go ahead.

Don't work under or about any engine under steam until you know that the throttle is closed and locked and the relief valves and cylinder cocks opened.

Don't go into fire-box or smoke-box of any locomotive or stationary boiler under steam pressure.

Don't move a locomotive at Round House until you know it is safe to do so.

Don't attempt to cross railroad tracks until you know that it is safe to do so.

Don't stand close to tracks when hot metal or cinder cars are passing.

Don't run an engine or cars over turn-table unless it is latched.

Don't fail to protect yourself, when necessary to work under or about engines or cars, by placing track targets at the outer ends of tracks between the switch and nearest car or engine, and in plain sight from the switch.*

Don't fail to report defective tracks, cars, or safety appliances at once.

Don't get excited and "cuss" and swear when things go wrong, — if you do you are liable to confuse others and cause an accident.

Don't take out a piece of track until after placing track target at proper distance on each side of same.

Don't use intoxicating liquors.

Don't fail to report all cases of carelessness or disobedience of rules coming to your attention, and caution parties at fault.

Don't fail to warn your fellow workmen of any obstructions or conditions which might endanger them.

Don't go into places of danger, or order your men to do so.

* When cars are jacked up to remove trucks, they should be supported by suitable horses, and not by the jacks alone.

CHAPTER 30

CHEMICAL WORKS, LABORATORIES, ETC.

(For definitions and properties of various dangerous chemicals, see also Chapter 42.)

MECHANICAL HANDLING

In working with chemicals which may cause burns or other injuries, it is advisable to minimize the exposure by providing mechanical means for moving and pouring them, wherever practicable.

The commercial acids are commonly handled in carboys, for which safety carriers may be provided. For emptying the carboys, an emptying pump, or a device for tipping or inclining the carboy, is highly advantageous. This device should be fixed rigidly in position, wherever conditions will permit, and arranged so as to discharge into a permanent trough or vessel of some sort. The provision should be such as to eliminate danger to the person using the device from the splashing of the liquid. This result can often be secured by providing a lever for operating the tipping device, which allows the operator to stand at a safe distance.

Where acid is received in tank cars and stored in quantities, it is well to have the storage tanks located underground so that they can be filled by gravity from the car. Small receiving tanks may be located in the departments using the acid, to which it is forced by the application of compressed air to the storage tank. The receiving tanks should be located at such a height that the acid runs by gravity to the receptacles in which it is used. This arrangement practically eliminates exposure to employees from the acid while it is being handled. (See Figure 3, Page 263.)

USE OF RUNNING WATER

One of the most important safety provisions, where injurious chemicals are handled in liquid form, is clean running water which may be used promptly for washing hands or other members accidentally splashed.

It is desirable to have a small flexible hose from which a moderate jet of water can be directed into the eyes, in case they should be affected; or the head may be plunged into a vessel of clean water and the eyes opened and closed underneath the surface so as thoroughly to cleanse them. Eye-cups may be used for applying water in places where temporary work is being done and running water is not available.

The important thing is to dilute the chemical as quickly and thoroughly as possible, in order to minimize its effect.

EXHAUST SYSTEMS

In some chemical processes where harmful fumes or dusts are generated, exhaust systems may be needed for the protection of employees, as mentioned in Chapter 9. (See Figs. 1 and 2, Page 65.)

If it is impracticable to remove dangerous dusts completely by means of an exhaust system, individual respirators may be required.

The General Chemical Company has prepared an excellent schedule of safety provisions, which is given to its employees in printed form. This schedule is quite specific and comprehensive, and contains many valuable rules. Permission has been granted to reproduce it here, and the sections dealing particularly with the chemical industry follow. The material has been divided into Instructions for Superintendents, and Rules for Foremen.

"INSTRUCTIONS FOR SUPERINTENDENTS

I. Entering of Tanks or Confined Spaces.
II. Cleaning of Tanks and Chambers.
III. Cleaning of Sulphuric Acid Tanks on Tank Barges.
IV. Rules for Working in Gassy Places and Use of Goggles.

I. Entering of Tanks, Confined Spaces, etc.

1. It is the desire of this Company that tanks and similar apparatus be cleaned from the outside; it is directed that no workman be requested or permitted to enter any tank-car tank, acid-storage tank, or any other kind of tank or chamber, or any similar piece of apparatus of any description, or any flue or still or any confined space, for any purpose whatsoever, unless specially ordered so to do by the Superintendent, and then only where such action has been determined by the Superintendent to be necessary, and after every effort has been made to accomplish the required work from the outside.

2. No workman shall be specially ordered by the Superintendent to enter any such tank, chamber, apparatus, flue, still, or any confined space, until the Superintendent shall have ascertained that the physical condition of the workman is such that he is reasonably fit to perform the proposed work without incurring danger to his health.

3. The entrance of a workman into any such tank, chamber, flue, still, or confined space, will then be permissible only after the same has been personally inspected and pronounced in safe condition by the Superintendent, and also after it has been demonstrated that the required work cannot be done from the outside, as hereinafter directed, and after having introduced a jet of compressed air, or, if feasible, air from a power-driven blower, near the bottom of the piece of apparatus or place, for a sufficient period to dislodge and displace *all* gases which may have remained dormant. Compressed air must also be kept flowing into the place while workmen are inside.

4. No workman shall be permitted to enter any covered tank, or open tank over 4 feet in depth, or piece of apparatus, or any other confined space, without first having a heavy leather strap or thoroughly tested rope securely fastened around his body under the arms; the other end of such strap or rope must be securely tied outside and attended by two workmen, who must remain until the man working inside the tank or similar piece of apparatus has finally emerged. Other aid must also be within easy call. (See Fig. 3, P. 277.)

Note: — The above prescribed use of a rope may be omitted in cleaning a no. 1 coke box or a no. 2 coke box, provided a ventilating fan or jets of compressed air be kept going continually in these pieces of apparatus during the progress of the work.

II. Cleaning Tank-Car Tanks, Acid-Storage Tanks or Chambers, or other Similar Tanks and Chambers.

Instances have occurred where customers have permitted weakened acid to remain in tank-car tanks, after discharging. This material should be removed as soon as possible after the arrival of the car at a works. Sediment should not be permitted to accumulate in tank-car tanks.

Cleaning of tank-car tanks, acid-storage tanks or chambers, or other similar tanks and chambers, must be done so far as possible from the outside, and the sending of workmen into such apparatus is to be done only in exceptional cases, and then by direction of the Superintendent personally, and after all the precautions set forth in Article I on the subject of Entering Tanks, Confined Spaces, etc., have been taken.

During the entire period a workman is inside any such tank, piece of apparatus, or confined space, he must wear an approved respirator, and in cases of tank-car tanks two streams of compressed air must be kept flowing into the car tank during the workman's presence therein. (See Fig. 1, P. 277.)

Tank-Car Tanks. 1. The cleaning of tank-car tanks should be effected from the outside by means of a hose, preferably of $2\frac{1}{2}$-inch diameter, fitted with a handle to permit the nozzle being introduced into the dome and pointed in any direction. The nozzle may be fitted with elbows on the end of a one-inch pipe, for the purpose of being lowered through the dome. Heavy wire may be used to support and direct the nozzle inside the car, if preferred; and it may be found advisable to employ two streams of water where facilities for so doing exist. Instead of a fire-hose nozzle lowered through the dome, a long piece of two-inch pipe, so bent as to permit its being introduced through the dome and extended toward either end of the tank about one-quarter of the tank length, may be employed.

By this method, when the cleaning of one end of the tank is completed, the nozzle must be withdrawn, turned round and entered through the dome in the opposite direction.

2. If a car is equipped with a cleaning outlet the blank should be removed before the cleaning is started, and if there is a bottom outlet, the cock should be opened previous to starting the cleaning. Before removing the blank from the cleaning outlet, it should be propped from the track tie with a stick to hold it in place while removing the bolts. After all bolts are removed, the stick is knocked away and the blank pushed off, care being taken that the workmen remain at a safe distance.

3. If the sediment in the car is not dislodged by the force of the water, this may be accomplished by using a hoe, fitted with a blade which conforms to the curve of the tank, and having a flexible handle of sufficient length to enable the workmen to reach the ends of the car through the dome. The stream from the hose should be played alternately towards the opposite ends of the car, hoeing continuously and leaving the outlet open. In cases where water under high pressure is available, hoeing will frequently be found superfluous.

4. Top-outlet cars may be run partially or completely full of water and the cleaning water run out by means of a two-inch syphon, the scraping with a hoe being constant to prevent settling of the sediment. In some cases it will be found necessary partially to fill the car a second time, and it may also be found feasible to work with a continuous inflow and outflow of water for a while, with constant hoeing as an aid to keeping the sediment in suspension.

If necessary, after the first cleaning with water, the cock may be closed or the blank replaced, and a water solution containing about 20 pounds of soda ash introduced with the fresh wash-water. Treatment with soda ash is not advised until the car has been thoroughly washed, and will generally not be found necessary except where the car is to be entered. After running off the soda-ash water, a final rinsing with the hose is necessary.

5. Instead of a syphon, the cover may be replaced and the contents blown out through a two-inch pipe having a drip piece of sufficient length to form a syphon. This method is not so effective as the previous one, because the quickly settling sediment is not kept in agitation during the discharge of the tank contents.

6. Exceptional cases may occur where the sediment is caked so hard as to require picking off by hand. In such instances the washing, as indicated above, should be carried out as completely as possible, and attempts should be made to dislodge the sediment by the use of long-handled hoes. If this treatment is not effective, the tank should be run completely full of water in order to dislodge any gases, or a jet of compressed air should be blown into each end of the tank for a sufficient period to accomplish the same object; and if a workman is sent inside, these two streams of compressed air should be kept flowing during his presence there.

7. After the washing is completed, the tank can be sponged dry without requiring a workman to enter it, by means of a large sponge on the end of a rod. The diluting effect of the little water which clings to the tank sides will be so small as to be negligible.

Reports from all Superintendents indicate that the majority have found it perfectly feasible to clean tank-car tanks by means of a firehose in practically all instances.

Chambers. Before proceeding with work of any kind within a Sulphuric Acid Chamber, and in particular the removing from the bottom of the sediment generally known as chamber-mud, holes sufficient in number and size must be cut in the curtain and top of the chamber, and the chamber aired either naturally or by artificial means until, in the opinion of the

Fig. 1. Motor-Driven Ventilating Fan used at Manhole in Street.*

Fig. 2. Helmet, with Hose Connection and Bellows for supplying Fresh Air.†

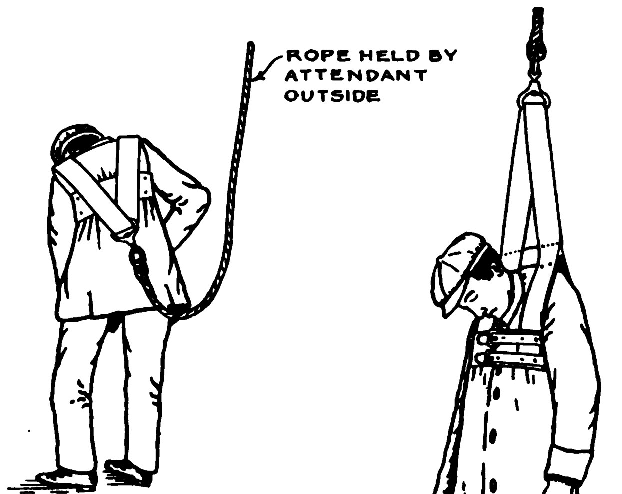


Fig. 3. Safety Belt with Rope.

Whenever it is necessary for men to work in manholes, tanks, or other compartments where noxious or explosive gases or vapors may be encountered, provision should be made, so far as practicable, for thoroughly ventilating the compartment before any one enters it. A device for this purpose is shown in Fig. 1.

Where complete ventilation is impracticable, equipment such as that illustrated in Fig. 2 may be used for supplying the workmen with fresh air. The weight of the air-hose is carried by a belt, thus leaving the hands free.

If there is any possibility of asphyxiation in work of this kind, a safety belt and rope such as that shown in Fig. 3 should be used, the rope being watched constantly by an attendant outside.

Where this provision is not made and an accident occurs, there is danger of the rescuers being overcome in attempting to reach the first victim, and several lives may be lost successively under such conditions.

* Courtesy of The New York Edison Company.

† Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

Superintendent, all noxious gases have been replaced by atmospheric air. It being possible that, even after taking the above precautions, gases may be emitted from the chamber-mud during the cleaning process, all workmen sent within Sulphuric Acid chambers must, while inside, wear Koenig or other approved respirators, and a heavy strap or rope about the body under the arms, the other end of such strap or rope being securely tied outside; and a foreman must remain constantly present to oversee and direct.

III. Cleaning Sulphuric Acid Tanks on Tank Barges

The cleaning of Sulphuric Acid tanks on tank barges must be accomplished during ordinary working hours, namely, between 7 A.M. and 6 P.M.

The use of Sodium Carbonate for neutralizing Sulphuric Acid in these tanks preparatory to cleaning is prohibited.

A water solution of Sodium Hydrate should be used for neutralizing Sulphuric Acid in these tanks preparatory to cleaning, and care should be used in the preparation of this solution to prevent injury from Sodium Hydrate, which is caustic.

The cleaning of these tanks must be accomplished by employees of the Works, and is not to be done by a barge crew.

Before cleaning one of these tanks, the manhole cover and the air-inlet hole-cap must be removed, and a stream of air must be injected through the 5-inch inlet hole by means of a power-driven blower, for a period of several hours, or until any confined gases have been emitted from the tank.

Before cleaning these tanks they must be inspected and properly prepared, in accordance with the regulations regarding the cleaning of tanks, issued to all superintendents.

Each workman while engaged in cleaning these tanks must wear a rubber coat, rubber trousers, and rubber boots.

During the entire period that a workman is within one of these tanks, another workman must be stationed within that tank, and directly beneath the manhole, and this workman must be equipped with a woven-copper-wire rope, securely fastened around his body under the arms, the other end of such rope to be carried outside the tank and continuously attended by another workman. This wire rope, to be not less than 70 feet in length, and to consist of woven copper wire sufficiently heavy to sustain a weight of 300 pounds, and covered with heavy rubber composition insulation.

The workman stationed beneath the manhole must be also equipped with a rope not less than $\frac{1}{2}$ inch in diameter, and 20 feet long, coiled and fastened at his belt for emergency use.

The workman within the tank beneath the manhole, and the workman outside the tank attending the rope, must remain at their respective stations until every man working inside the tank has finally emerged.

Goggles. 1. You are required to requisition to the purchasing department for such number of pairs of goggles as may be necessary to equip all workmen when employed under conditions making them liable to injury of the eyes from acid-splash, flying particles, or other causes or conditions likely to injure the eyes.

2. This Company appreciates that it cannot compel the workmen to use goggles, but they are supplied for the workmen's use, and Superintendents are directed to instruct the workmen to use them, and how to avoid any inconvenience therefrom. Irritation of the skin from wearing goggles is generally caused by the accumulation of perspiration under the rims. Washing the face before and after using goggles will prevent this irritation.

IV. Rules for Working in Gassy Places and Use of Goggles

Superintendents are directed to have copies of the following Rules for Working in Gassy Places and Using Goggles, printed upon cards measuring not less than 11 inches by 14 inches, which shall be conspicuously posted in numerous places about the works in their charge.

Such rules shall be printed in English, German, Hungarian, Slavonic, Italian, and such other languages as may be necessary properly to inform all work-men thereof.

Rules for Working in Gassy Places

1. Workmen are forbidden to enter any tank-car tank, acid-storage tank, or chamber, or any other kind of tank or similar piece of apparatus, or any flue or still, or any confined place, for any purpose whatsoever, unless specially ordered so to do and detailed for that work by the Superintendent.

2. Workmen are forbidden to enter any tank-car tank, acid-storage tank, chamber, or similar confined space for any purpose, unless secured by one end of a thoroughly tested rope or strap, passed around the body just under the arms and so knotted back of the shoulder that it cannot slip. The other end of the rope must be securely tied outside and attended by two workmen who must remain until the man working inside has come out. Additional aid must also be within call.

3. Air-Hoods or Respirators are provided, and must be worn by workmen whenever directed so to do by the Superintendent or a foreman.

4. Lights, flames and sparks must be avoided and guarded against wherever the presence of inflammable or explosive gas is known or suspected.

Goggles

5. All workmen when working where there is danger of injury to the eyes from acid-splash, flying particles, or other conditions likely to affect the eyes injuriously, must wear goggles, which are supplied by the Company. No irritation of the skin will result from the use of goggles if the workmen wash their faces immediately before and after using them. (See Figure 2 and other illustrations on Page 375.)

General. The regulation of the details of the entire question of the protection of workmen is placed specifically within and under the jurisdiction of each Superintendent, and the responsibility for occurrence of accidents, where avoidable by the use of the preventive methods enumerated, rests upon him.

Each Superintendent is required to place in the hands of each Assistant Superintendent, Assistant to the Superintendent, Works Chemist, First Assistant Chemist, and Foreman of every grade employed at the works in his charge, a printed copy of this circular letter.

Each Superintendent is also required to ascertain at the expiration of each period of six months that each member of his staff above enumerated has in his possession a printed copy of this circular letter.

Each Superintendent is required to keep readily accessible at the works and in working condition, as many approved respirators as may be required for use under conditions here in described, and upon any and all occasions where their use is determined to be necessary by the Superintendent.

Each Superintendent is directed to designate one or more persons of requisite intelligence to render first aid to injured employees, and shall direct that such person make a study of "first aid to the injured" methods, for the purpose of enabling him to efficiently render first aid when required.

RULES FOR FOREMEN

General

You are notified that not only is it your duty as a foreman to see that the instructions of the Superintendent are carried out, and that work under your direction is properly performed, but also that you share with the Superintendent and other members of his staff the responsibility for the safety of the workmen under your immediate charge.

You are directed to acquaint each workman, when placed in your charge, with all of the following rules which apply to the duties of the workman, and to make sure that he understands such of these rules as you read to him, and it is one of your special duties to see that these rules are understood and obeyed.

You are directed to use the greatest care to prevent accident to yourself or any workman, and you are directed to obtain instructions from the Superintendent or his representative whenever you are uncertain regarding the safety of work, under way or proposed, or have any doubts regarding the manner in which any piece of work should be done.

No workman is permitted to engage in work of any character at a Works except upon the specific order of a foreman or the Superintendent or his representative.

Fire

You are directed to obtain from the Superintendent, and to enforce, instructions regulating the carrying or using of naked lights, lighted matches, candles, cigars, cigarettes, or pipes, for the reason that rules in regard to the use of naked lights and smoking are of necessity not uniform at all Works; each Superintendent being required to frame rules covering these matters in accordance with the requirements of local conditions.

Lead-burners require naked lights almost constantly, and machinists have to use them frequently, but it is your duty to see that the Superintendent's rules in regard to smoking and the carrying and use of naked lights are so enforced as to reduce the fire-risk to a minimum.

Nitrate of Soda ($NaNO_3$) and Chlorate of Potash ($KClO_3$).—You are directed to use special precaution against fire in and about any place where either of these materials is stored. The contact of either of them with burning substances makes a fire of the greatest violence and almost impossible to control. You are especially required to see that naked lights, lighted matches, cigars, cigarettes, or pipes, are not brought into or about the places where one or both of these materials are stored.

Dangerous Gases

You are notified that Sulphuretted Hydrogen (H_2S), Sulphuric Anhydride (SO_3), Hydrochloric Acid (HCl), Nitric Acid (HNO_3) Oxides of Nitrogen (Red Fumes), Hydrofluoric Acid (HF) and Fuel Gas, natural or manufactured (mostly CH_4 and CO), are *poisonous gases* when inhaled in considerable quantities, and that Sulphuretted Hydrogen, Fuel Gas, Acetic Acid, Hydrogen, Naphtha, and Gasolene may form *inflammable or explosive gases* when mixed with atmospheric air. You are therefore forbidden to enter, or to permit any workman to enter, except by direction of the Superintendent, any tank-car tank,* acid-storage tank or chamber, or any other kind of tank or similar piece of apparatus or any flue, still or confined space except on specific orders from the Superintendent, and you are also forbidden to enter any piece of apparatus, or any place whatsoever where you may come in contact with or be compelled to breathe any of the above specified gases or any other gas except air.

Gases which burn

You are forbidden to have, or carry, or employ, any naked light near or about any of the inflammable gases enumerated, that is: Sulphuretted Hydrogen, Fuel Gas, Acetic Gas, Hydrogen, Naphtha, and Gasolene, whether mixed with air or not, or to allow any one to do so.

Entering Apparatus Tanks

You are warned that the entering of tank-car tanks, acid-storage tanks or chambers, or any similar piece of apparatus of any description, or any flue or still, or any confined space, may be dangerous unless the tank or space has been ventilated and prepared for entrance, since acids may still be present or dangerous gases may have formed; and you are therefore forbidden to enter, or to permit any workman to enter, any tank-car tank, or other place as above stated, except when specially ordered to do so by the Superintendent.

Stirrers

You are forbidden to enter or to allow any one else to enter, any piece of apparatus equipped with a mechanical stirrer, until you have made sure that the belt has been removed from the driving pulley; or, if connected by a clutch or other mechanical device, until the driving mechanism has been thrown out of gear and secured in a safe manner.

* The following caution, contained in a pamphlet giving directions for unloading acid from tank cars issued by the General Chemical Company, is of interest in this connection.

"Acids reacting on iron generate hydrogen, which, with air, produces an explosive mixture. Effective means, should, therefore, be taken to KEEP LIGHTS, OR SPARKS, AWAY FROM OPEN CAR DOME. For the same reason it is *unsafe* to use a hammer and chisel within, or around, any opening of a car."

Pressure

You are warned not to open any apparatus before you have made sure that there is no longer any *pressure* within it, or to allow any one to do so.

Acids

In many of the Works the chief things made are acids. In general these are liquids which when left in contact with the skin produce dangerous and slowly healing sores, and when left on the clothes burn holes in them or slowly rot them if the acids are weak. In nearly all of the Works acids must be handled, and in order to avoid accidents certain precautions must be observed, such as the wearing of goggles, rubber boots, rubber gloves, etc. These means of protection are placed in your charge and are to be used by yourself, and you are to cause the workmen in your charge to use them, whenever you believe it necessary, or as directed by the Superintendent or his representative.

Acids diluted with water burn less than those not diluted with water; the stronger the acid the more powerful its effect. The relative strength and danger of acids stand in the following order: —

a. Fuming Sulphuric Acid (Oleum).
b. Strong Nitric Acid.
c. Sulphuric Acid 66° and 98 per cent.
d. Hydrofluoric Acid.
e. Dilute Nitric Acid.
f. Sulphuric Acid 60°.
g. Hydrochloric Acid.
h. Dilute Sulphuric Acid.
i. Acetic Acid.

Oleum is the strongest and most dangerous of the acids; Acetic Acid is the least dangerous.

Empty Drums and Carboys

You are cautioned not to run acids into carboys, drums or tank cars which have previously contained an alkaline substance, such as Ammonia, Caustic Soda, Carbonate of Soda, etc., or to allow a workman to do so, until the container has been thoroughly washed with water. You are also cautioned not to run an alkaline liquid, such as Ammonia, Caustic Soda, Carbonate of Soda, etc., into carboys, drums or tanks which have contained acid, or to allow a workman to do so, before the container has been thoroughly washed with water. Great heat is produced by the action of acids on alkalines, and this may cause violent spattering.

Safeguards

You are warned that injuries and burns are frequently caused by acid-splash, and you are directed to employ, and to cause workmen to employ, safeguards provided by the Company, namely goggles, respirators or hoods, rubber gloves, and rubber boots, as directed by the Superintendent or his representative, whenever and wherever he shall so direct; and you are also warned to use every care to prevent such injury from acid-splash to yourself and the workmen under your charge.

You are notified that it is your duty to see that all hoods, respirators, goggles, gloves, boots, clothing and any and all safety appliances in the department under your charge are kept in a continuous condition of complete repair.

Injury to eyes

You are warned that eye injuries are frequently caused by acid-splash, and you are therefore directed to use the utmost care to prevent injuries of this nature, and also you are directed to use the goggles provided by the Company for the purpose of preventing injury to the eyes from acid-splash, flying particles, or any other cause or conditions likely to cause eye injuries, whenever and wherever directed by the Superintendent or his representative, and in such manner as he may direct, and to see to it that workmen under your charge use these safeguards when advisable.

Piping

You are warned that all acid pipe lines and fittings and attachments, such as cocks, faucets, etc., are a constant source of danger or injury from acid-splash, acid-spray, acid-drip, etc., both in cases of pipe lines in use and full of acid, and also in pipe lines temporarily out of use, and even in those entirely out of use, owing to the possibility of acid spurting from a break or leak in a pipe or fitting, or splashing or spurting from the plug or a cock or faucet, or issuing through a cock or a faucet.

You are directed to use the utmost care in all work upon acid pipe lines and fittings and attachments, in order to avoid injury from acid-splash, or spray, or stream, and you are directed to instruct your workmen in regard to the required work before allowing them to proceed with work upon acid pipe lines and fittings, and connections and attachments.

Eye Cup

You are directed that, in all cases, before permitting workmen to start to disconnect, open, repair, or remove any pipe faucet or any apparatus, containing or that have contained any liquid other than water, you must provide, and have continually within easy reach of the workman or workmen, a pail full of clean water, and an eye-cup of metal or glass. In case acid spurts into the eye of any one, you must see that he instantly applies the eye-cup full of water, and that throwing his head back he opens the affected eye, and turns it from side to side so that the water will dilute the acid in an effort to prevent serious injury.

Injuries — First Aid

Whenever any one receives an acid-splash on any part of the body immediate application for First Aid must be made, or First Aid be immediately summoned; and while awaiting First Aid the acid should be quickly wiped off as completely as possible with a dry cloth or waste, and then the place immediately washed with plenty of water.

You are notified that at each Works one or more persons are detailed by the Superintendent to give First Aid to every workman injured in or about the premises, and it is your duty to learn who is in charge of the work of giving First Aid.

You are directed to give notice and see that application is made for First Aid at the Works immediately following an injury to yourself or a workman.

You are directed to see to it that workmen in taking up new work are instructed with special care as to the precautions to be observed in doing that work.

You are notified that you will be held strictly accountable for any accident happening in your department. The excuse will not be accepted that other foremen, such as Foreman Carpenter, Foreman Pipe-fitter, etc., have been notified to make repairs but have not done so, unless notice of such delay has been given the Superintendent. Neither will the excuse be accepted that safety appliances, such as rubber boots, gloves, goggles, etc., were not used because none were to be had in the store-room, unless notice to that effect has been given to the Superintendent."

CHEMICAL LABORATORIES

The following data are based chiefly upon information collected by the Committee of Safety of the United States Steel Corporation, representing safety practice for laboratories recommended by the subsidiary companies of that concern: —

Laboratory Equipment

1. Each laboratory should be provided with a suitable hood to insure proper ventilation and freedom from fumes. (See Figure 1, Page 65.)

2. Workmen using wash-bottles should be furnished with individual apparatus. Special individual drinking glasses should also be supplied, and the men should be instructed not to drink from beakers or other vessels used in their work.

3. Running water should be available at all times for quickly rinsing away any injurious chemicals which may come in contact with hands or other parts of the body. A small flexible hose from which water flows at a moderate pressure may be used to advantage for washing chemicals from the eyes, or the head may be plunged into a vessel of water and the eyes opened and closed underneath the surface.

4. A suitable syphoning arrangement, operated by water or air-pressure, should be provided, and the attendants should be instructed not to start syphons by the mouth.

Fig. 1. Device for Carrying Carboys.*

Fig. 3. Carboy Tongs.*

These devices can be quickly attached or detached, and practically eliminate danger of injury while carrying carboys of acid. Without facilities of this kind the carboys may be dropped and broken or men may be strained in lifting the heavy weight.

Fig. 2. Details of Device for Carrying Carboys.*

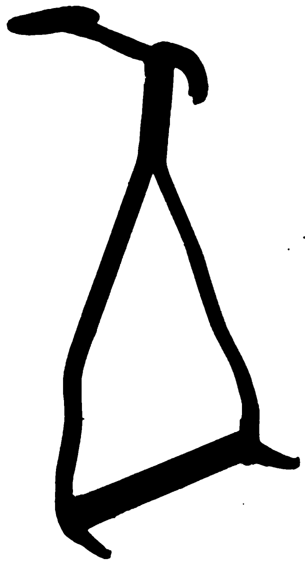


Fig. 4. Detail of Carboy Tongs.*

* Courtesy of General Electric Company.

5. The large carboys in which supplies of acids and alkalis are received should be conveyed to and from the laboratory in special carriers made for that purpose. (See Page 283.) For emptying carboys a pump, rocker device, or inclinator should be provided. (See Page 285.)

6. All reagent bottles should be kept properly labeled and in good condition at all times. Any bottle found without a label, or the contents of which are in doubt, should be reported to the Chief Chemist, and the contents thrown out unless they can be properly identified.

7. All containers of active poisons, such as Chloride of Mercury, Cyanide of Potassium, etc., should be specially labeled or marked in a conspicuous manner. In some instances the practice has been adopted of chaining a small bell to the neck of any such bottles.

Laboratory Practice

8. No analyst should be permitted to engage in any operation involving possible danger to himself or others, until fully instructed therein. Foremen should satisfy themselves that each analyst has a proper realization of the danger before attempting any hazardous task or undertaking.

9. Transferring acids and ammonia to bottles should be done in a well-lighted and well-ventilated building, — preferably under hoods equipped with exhaust flues.

10. When opening new bottles containing liquid chemicals, or pouring such chemicals from large bottles, both hands should be used. Bottles should be placed in sink or on drip-board, and inclined at such an angle that the flow will be gentle without splashing.

11. Acids or other dangerous chemicals should not be poured from one bottle to another with wet hands, and bottles should not be handled by the neck. Glass stoppers should be laid in a clean place or held between the fingers.

12. Funnels should preferably be used when pouring the contents of large bottles into smaller ones. Bottles should not be turned upside down in funnels and left to drain, but should be emptied by hand.

13. Concentrated acids should never be mixed with strong ammonia. When filling acid or ammonia bottles, be absolutely certain to have the right bottle, properly labeled, before pouring from carboy.

14. Great care should be used in handling bromic or hydrofluoric acid; a slight quantity of these acids, or even their vapors, may inflict dangerous burns, and their fumes are very injurious to the eyes.

Crucibles which contain hydrofluoric acid should never be handled with bare hands.

Wax containers for hydrofluoric acid should be kept in a cool place where the wax will not soften. In picking up these containers be sure that the wax has not been softened by heat before handling the bottle.

Operations involving the evolution of harmful fumes, such as bromine, chlorine, fluorine, etc., should be conducted only under a hood with good draught.

The hands should be washed immediately if there is any possibility of acids being on them.

15. Carboys of solution should be made up where used, and not carried about the laboratory or lifted on to shelves. It is always well to wipe off table or floor carefully before setting down a large flask or naked carboy full of solution. A small particle such as a pebble or grain of sand may rupture the flask or carboy, especially if it is suddenly jarred.

16. In diluting sulphuric acid, the acid should always be added to the water, — not *vice versa;* the acid should be poured slowly, the solution being stirred meanwhile in order to prevent the acid from settling to the bottom.

17. Hot crucibles should never be placed in acid or water, and a hot fusion should not be dropped into a liquid without extreme care to avoid danger from spattering.

18. In forcing a glass tube or rod through a hole in a rubber stopper, the hands should always be protected by gloves or cloth. Ends of glass tubes and rods used for this service should be fused. It is well to use a screw motion and take plenty of time, when inserting rod in stopper.

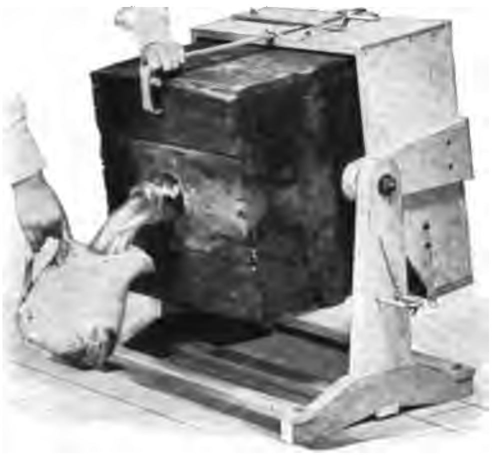


Fig. 1.

Fig 2.

Device for Pouring Acid from Carboys.*

Fig. 3. Pump for Emptying Carboys.*

Fig. 4. Pump for Emptying Carboys.*

Fig. 5. Carboy Inclinator.*

This pump is connected to a bell-shaped piece of rubber which is placed inside the neck of the carboy. A curved pipe extends through the rubber attachment to the bottom of the carboy. Air is pumped into the carboy, forcing the acid to flow from the pipe. The pressure may be released to stop the flow of acid by removing the hand, which covers an air-vent in the handle of the pump.

Fig. 3 shows a different make of apparatus designed for the same purpose. With these devices the operators' eyes can be kept well out of range of splashing acid.

* Device patented.

19. All broken glass should be promptly cleared away and placed in refuse jar. All liquids spilled on tables or floors should be wiped up immediately.

20. Where gas or gasolene burners are used, care should be taken at all times to see that there is no leakage from same. All burners should be extinguished before leaving the laboratory, and it should be made certain that no gas is escaping before they are lighted again. In case a leak, or escaping gas, is discovered, the valve should be shut off and ample time given for gaseous mixture to clear away before any attempt is made to light it.

21. Safety matches only should be used in laboratories, and these should never be permitted to lie around loose; they should always be stored in metal or glass containers.

22. NEVER TASTE A CHEMICAL!

CHAPTER 31

TEXTILE EQUIPMENT

THE ordinary mechanical hazards of gearing, belting, chains and sprockets, etc., furnish a material percentage of all textile accidents. To these are added the special hazards of rolls, cylinders, and beaters common in this industry; these rolls or cylinders may be corrugated or covered with clothing containing sharp needle-like wires set at such an angle that they almost invariably draw in and mutilate a hand or other member which is once caught.

CAUSES OF ACCIDENTS

The common types of accidents on special textile machinery are well indicated by the following analysis of 557 accidents, which were reported consecutively from a number of textile plants in Massachusetts.

Rolls and Cylinders

	A*	B*	C*	Total
Openers and pickers	3	1	2	6
Cards	8	7	6	21
Lappers	1	4	2	7
Combers	1	2	5	8
Drawing Frames	4	2	1	7
Spinning and twisting frames	13	5		18
Winders and quillers	2	1		3
Slashers	1	2		3
Looms	1	3		4
Dye house machinery	7	7	5	19
Printing machines	1		1	2
Calenders	2	4	2	8
Cloth winders	1	2	1	4
Miscellaneous	2	1		3
Total	***48***	***40***	***25***	***113***

(Cleaning machine in motion....... 33)

Gears

	A*	B*	C*	Total
Openers and pickers		2	2	4
Cards	9	8	2	19
Combers	1		1	2
Drawing frames	1	3	2	6
Speeders	3	4	7	14
Spinning and twisting frames		9	3	12
Winders and quillers	1	1	1	3
Slashers	1	2		3
Looms	4	8	3	15
Dye house machinery		1	1	2
Printing machines	2		3	5
Miscellaneous	1	2		3
Total	***23***	***40***	***25***	***88***

(Cleaning machine in motion....... 36)

Belts and Pulleys

	A*	B*	C*	Total
Openers and pickers	3	2		5
Cards	3	3	1	7
Lappers	1		1	2
Mules		3	3	6
Spinning and twisting frames	3	2		5
Winders and quillers	1	1		2
Beamers		2		2
Looms		5	2	7
Braiders	1	1		2
Miscellaneous	1	1	1	3
Total	***13***	***20***	***8***	***41***

(Cleaning machine in motion........ 8)

Chains and Sprockets

	A*	B*	C*	Total
Pickers		1		1
Cards	1			1
Card lacing machines			1	1
Dye house machinery	1			1
Marline layers	1			1
Total	***3***	***1***	***1***	***5***

(Cleaning machine in motion........ 1)

Flying Shuttles, Pulleys, etc.

	A*	B*	C*	Total
Cards	1			1
Speeders		1		1
Reelers	1			1
Looms	13	19	1	33
Marline layers			1	1
Total	***15***	***20***	***2***	***37***

Flyers, Bobbins and Spindles

	A*	B*	C*	Total
Spinning and twisting frames	26	28	1	55
Speeders	6	15	4	25
Reelers		1		1
Winders and quillers		2		2
Marline layers		2		2
Balling machines		2		2
Total	***32***	***50***	***5***	***87***

(Cleaning machine in motion......... 2)

* "A" indicates no time lost; "B," less than two weeks; "C," more than two weeks.

	A*	B*	C*	Total
Miscellaneous Revolving Parts, Shafting, Couplings, etc.				
Cards	3		1	4
Lappers	1	3	3	7
Combers	2	1		3
Mules	1	4		5
Beamers		1	1	2
Shearers	2	2	1	5
Miscellaneous	3	5		8
Total	*12*	*16*	*6*	*34*
(Cleaning machine in motion		16)		
Miscellaneous Reciprocating Parts				
Pickers		2		2
Drawing frames	1	5	1	7
Mules		1	3	4
Spinning and twisting frames		2		2
Looms (principally between lay and breast-beam or frame)	38	69	8	117
Card lacing machines			1	1
Folders	7	11	3	21
Total	*46*	*90*	*16*	*152*
(Cleaning machine in motion		24)		
Grand totals	*192*	*277*	*88*	*557*
Per cent of total	*34*	*50*	*16*	

It will be noted that 192 of these accidents, or about one-third, caused no lost time; 277, or about one-half, caused less than two weeks disability; 88, or about 16% of the total, were relatively serious, causing more than two weeks' disability (or death).

Cleaning Machines while in Motion

One hundred and twenty of the above accidents, *or more than 20% of the total,* occurred while operatives were cleaning machinery in motion. This illustrates a common tendency in the textile industry. The loose waste or "fly," which is universally encountered, gathers on the gears and other parts of the machinery, and the operators are prone to try to clean it away while the machines are running. For this purpose they are likely to open or remove gear covers, where the latter have been provided, if it is possible to do so. (See Fig. 1, P. 294.)

It is advisable to have rules in effect prohibiting the cleaning of machinery while it is in motion, and to enforce these rules as fully as practicable. The difficulty of completely enforcing such rules, however, has resulted in the development of interlocking guards which take care of the matter automatically, since the guards cannot be removed while the machinery is in motion and the machinery cannot be started without the guard in place.

* "A" indicates no time lost; "B," less than two weeks; "C," more than two weeks.

MACHINE SAFEGUARDS

The interlocking principle is applicable, not only to gear guards, but to covers of revolving beaters and cylinders as well. These commonly run at high speed, and the momentum of the moving parts is sufficient to keep them revolving for some time after the belt is thrown on to the loose pulley. In many cases operatives have thus been injured by opening the cover and reaching into the machine after it had apparently stopped.

Such interlocking devices are required by the English factory regulations for the important types of textile equipment. (See "Report on Conferences between Employers, Operatives and Inspectors, Relative to Guarding of Machinery and Prevention of Accidents," for the year 1912.)

The following safeguards are recommended for textile equipment. Where new machinery is being ordered, these safeguards will be furnished by the machinery builders, if specified, but are likely to be omitted unless they are specifically called for in placing the order.

Openers and Pickers

Wherever the beaters are arranged so they can be reached while the machine is running, a locking device should be provided for the beater covers or doors. (See Figs. 1 and 2, P. 289.)

Cards

Cylinder covers should be provided with locking devices which prevent their being opened while the cylinder is revolving, or the machine being started without the cover in place. (See P. 289.)

It is well to have cover of "licker-in" screwed down so that it cannot be quickly removed, thus giving greater assurance that it will only be taken off when the machinery is shut down.

Fig. 1.

Fig. 2.

Locking Device for Beater-Cover and Window of Picker.

When machine is in running position (Fig. 1), a pin in left-hand end of lever A enters opening in beater-cover B, preventing its being lifted; right-hand end of lever keeps window C closed. Disc D, keyed to beater spindle, prevents lever A from being moved while beater is revolving, through its interference with pin E. After beater has stopped, pin E may be slipped through one of the holes in disc, permitting lever A to move horizontally out of engagement with beater-cover and window, so they can be opened.

Note filler in keyway, held in position by countersunk screws.

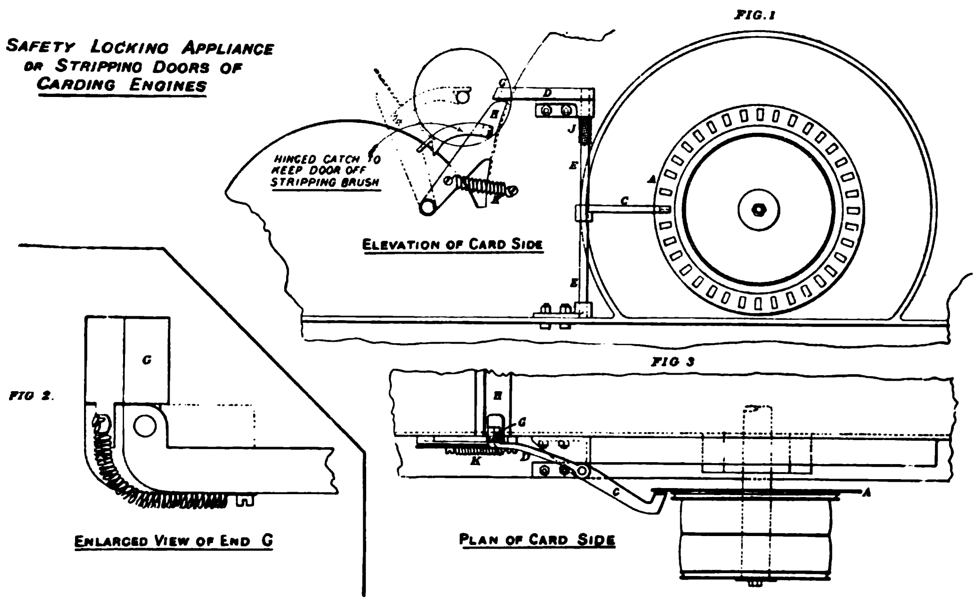


Fig. 3. Locking Device for Cylinder Cover of Card.*

In Fig. 3,—disc A, containing a number of apertures, is fastened to tight pulley. Arms C and D are carried by shaft E, supported by brackets attached to frame of machine. When machine is running, disc A prevents arm C from turning, and end G keeps cover closed.

When cylinder has stopped revolving, the end of lever C may be pushed through an aperture in disc A, thus moving arm G outward and permitting cover to be opened. After cover has been opened, spring J returns the arms to their former position, permitting cylinder to be turned for stripping. End G is hinged so as to permit cover to be closed without again moving arm D.

* From British government report. (See "Safeguards for the Prevention of Accidents in the Manufacture of Cotton," 1906.)

Fig. 1. Guard closed.

Fig. 3. Guards for Wool Card.

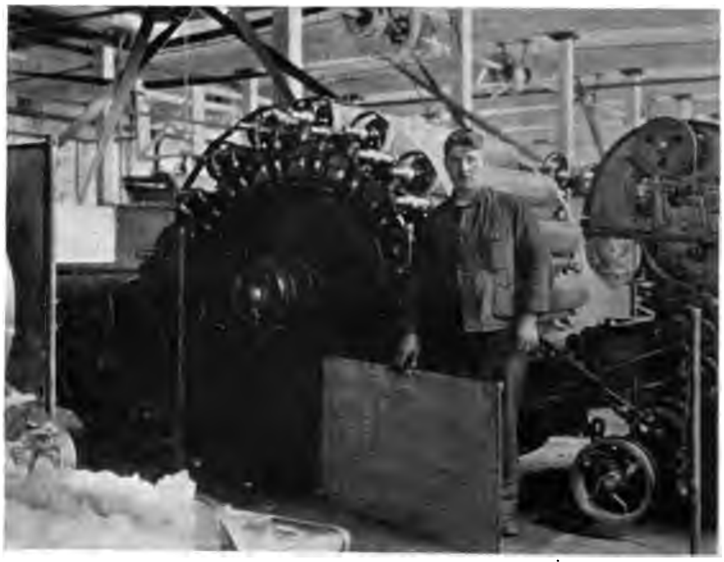


Fig. 4. Wool Card Guards removed.

Fig. 2. Guard open.

Figs. 1 and 2 show a type of guard that is applicable to Sliver and Ribbon Lap Machines, Derby Doublers, etc., a form of equipment on which many serious accidents have occurred.

The operator shown in Fig. 1 lost two entire fingers and parts of two others by having them caught in this machine.

The guard is entirely automatic in action, being locked in position when the machine is running, and opening as shown in Fig. 2 when the lap is completed.

Figs. 3 and 4 show protection for belts, pulleys, sprockets, etc., of wool Carding Machine. The guard is made up in sheet steel sections, shown in position in Fig. 1; these sections can be quickly removed, as illustrated in Fig. 2, when it is necessary to reach the machinery.

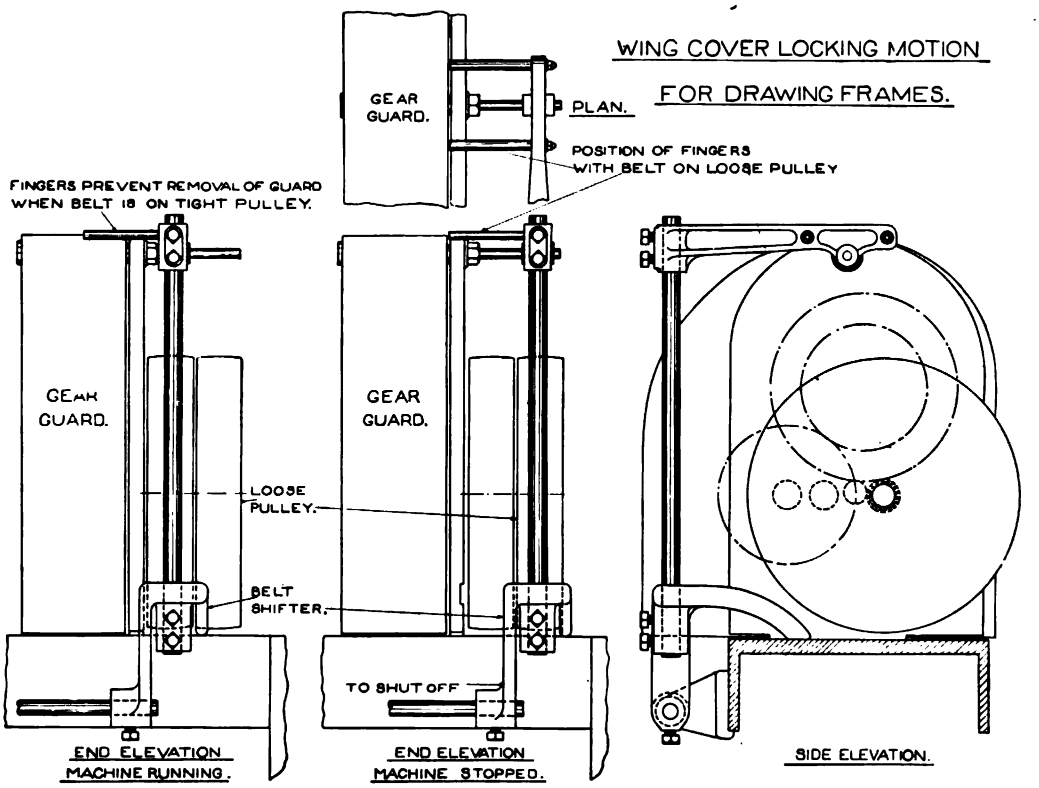


Fig. 1. Arrangement to Prevent Removal of Drawing Frame Gear Cover while the Machine is running.

Fig. 2. Belt Guards for Drawing Frames.

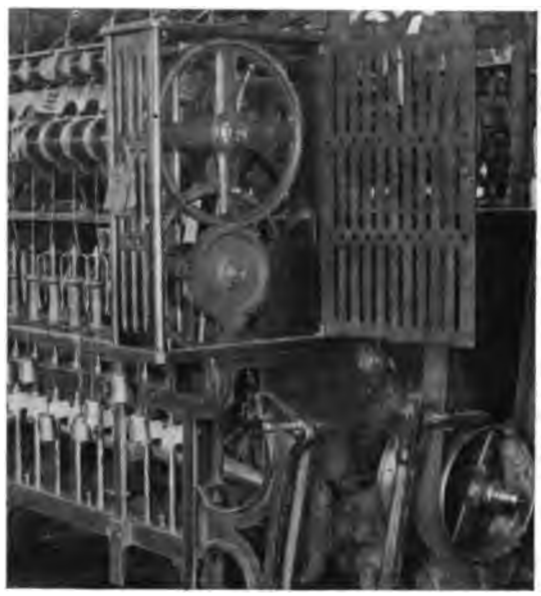


Fig. 3. Gear Guard for Coarse-Spinning Frame.*

Note also latch device for locking belt on loose pulley, in connection with shifter shown in Fig. 3.

*** Courtesy of Ludlow Manufacturing Associates.**

Lap Machines, Doublers, etc.

These machines should be provided with interlocking guards which will prevent the operator from coming in contact with the in-running rolls while they are in motion. (See Figs. 1 and 2, P. 290.)

Drawing, Slubbing, Roving, and Ring Spinning Frames, etc.

Gear covers, or doors, should be interlocked in such a manner that they cannot be opened while the machine is running and the machine cannot be started with the doors open. (See P. 293.)

Mule Spinning

Carriage wheels, rope sheaves and other parts where a hand might be caught and crushed, should be guarded, as shown on Page 295.

There should be at least 18″ clearance between the traversing carriage and any wall, column or other fixed structure against which persons might be caught and crushed.

It is well to protect the exposed sides of mule spinning frames by railings, where these frames are located adjacent to passageways or truckways in such a manner that there is danger of persons or trucks being struck by the moving carriage.

Weaving

Looms should be provided with shuttle guards to minimize the possibility of a shuttle flying out. (See Fig. 4, P. 294.) Shuttles threaded by suction through the lips should not be permitted, on account of their injurious effect on the health of the operatives.

Hand wheels of looms should be arranged so as to give sufficient clearance for the hand at all points around periphery of wheel. A number of accidents have occurred, where the clearance was inadequate, from hands being caught between wheel and gear or frame of machine.

Exposed belts, gearing, shafting, counterweights, etc., should be guarded on all types of textile machinery, and locking belt shifters should be provided. (See Chapter 17.) Revolving hand-wheels should be protected, — preferably by attaching a disc to the arms of the wheel. In this industry as in many others, loose or torn clothing, flying hair of women operatives, etc., are always liable to cause accidents, and rules prohibiting such conditions should be formulated and enforced.

BLEACHING, DYEING, AND PRINTING WORKS

The British factory regulations * outline good safety standards for this equipment; in addition to providing for the protection of gearing, belting, shafting, etc., and the railing of overhead platforms or runways, they call for the following special provisions in bleaching, dyeing, and printing works.

Bleacheries

Uncovered mixing and agitating pans are to be guarded to a height of 3′, if the edge is less than 3′ above the working platform.

Where liquor is prepared in kiers (which is to be avoided where possible) a mark must be placed on the puffer pipe of the kier to indicate when the kier may be entered with safety, and no one is to enter a kier until the level of the cloth in it covers that mark.

Adequate safeguards are to be provided and used to prevent the accidental admission of steam or liquid into a kier while any person is therein. The means to be adopted to be the "best possible having regard to the circumstances of each case." (See valve locking device, P. 79.)

Ladders of suitable length are to be provided and kept close at hand, available for use in case of emergency.

The working platforms of open kiers are to be at least 2′ 6″ below the edge of the kiers or securely guarded to such a height, and no one is allowed to stand on the edge of an unguarded open kier while plaiting down.

Pot eyes or guides of open kiers are to be so fixed as to allow the cloth to hang vertically within arms length of a person standing on the platform outside the kier. Every kier worked above atmospheric pressure is to be thoroughly examined at least once every twenty-six months

* See "Report of Conferences between Employers, Operatives, and Inspectors," 1914.

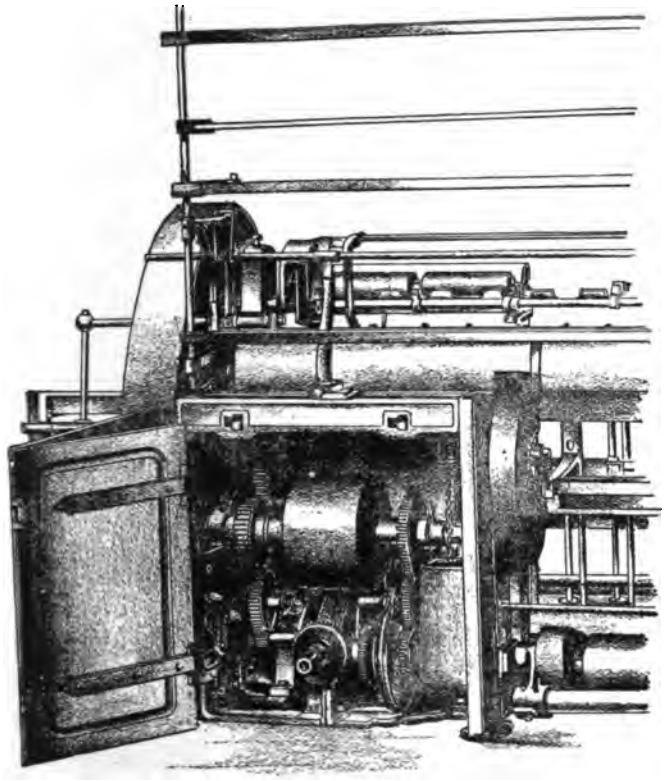


Fig. 1.

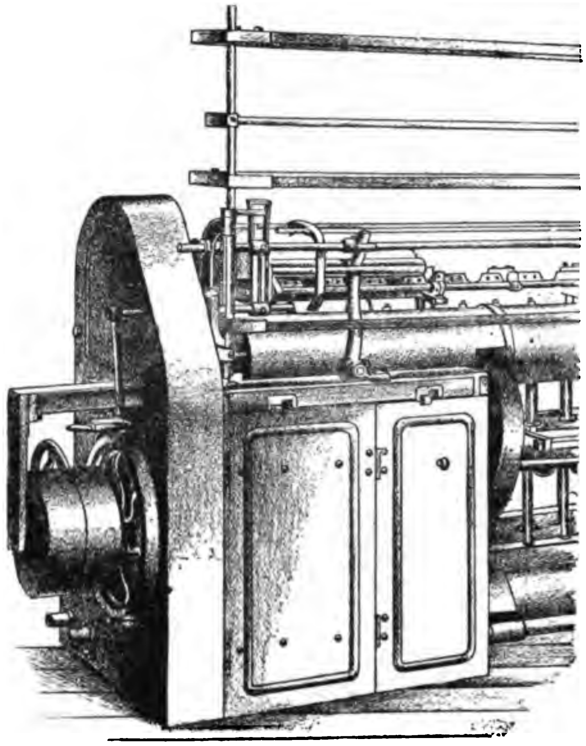


Fig. 2.

Door Locking Device for Speed Frame Gears.*

This device prevents door being opened while the machine is running, and the machine cannot be started until door is closed.

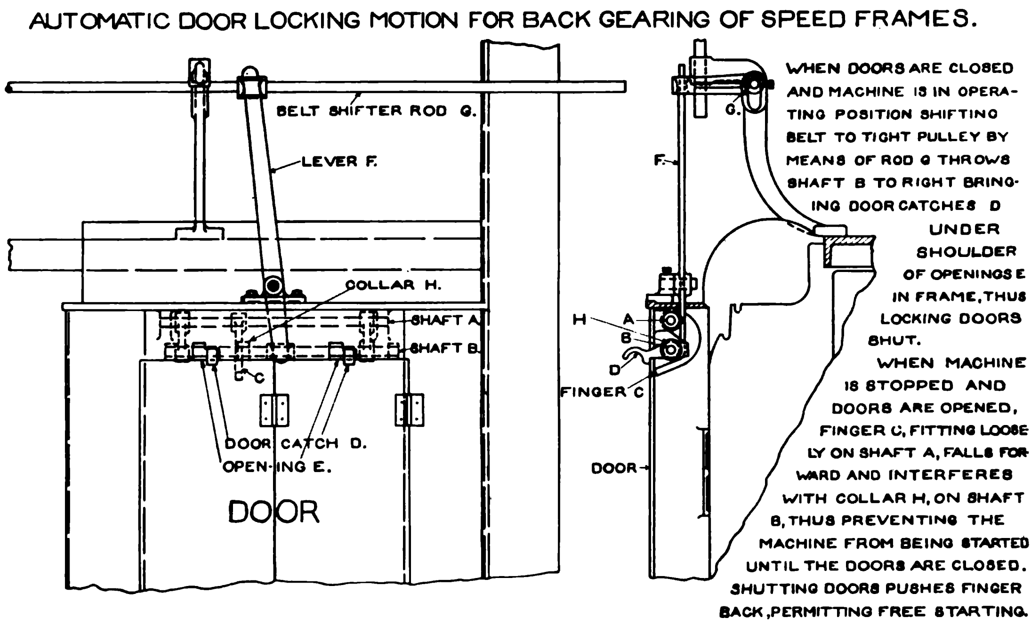


Fig. 3. Drawing explaining Operation of Door Locking Device.

* From British government report. (See "Safeguards for the Prevention of Accidents in the Manufacture of Cotton," 1906.)

Fig. 1. Scene of Gear Accident on Spinning Frame.

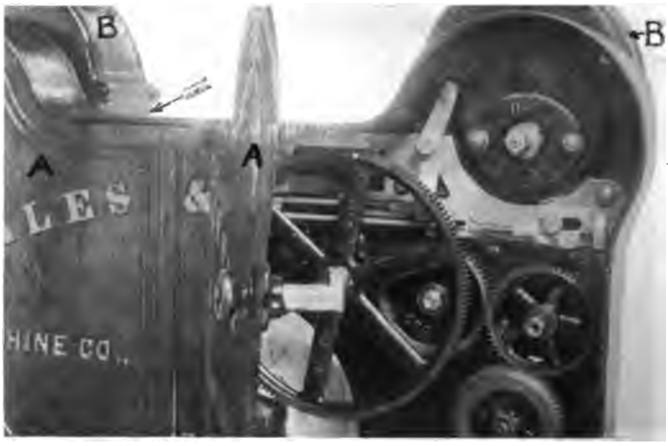


Fig. 2. Door Locking Mechanism for Spinning Frame.

The gears shown in Fig. 1 are provided with a good cover. This cover could be readily raised, however, as indicated in the photograph, and the hand of an operator who was cleaning the gears with the machine running, was caught and crushed.

Fig. 2 illustrates a mechanical device for interlocking swinging doors A, as well as gear covers B, with the starting mechanism, in such a manner that they cannot be opened while the machine is running. So long as one or more of the covers is open the belt shifter is locked on the loose pulley, and it is only free to move when all covers are in place.

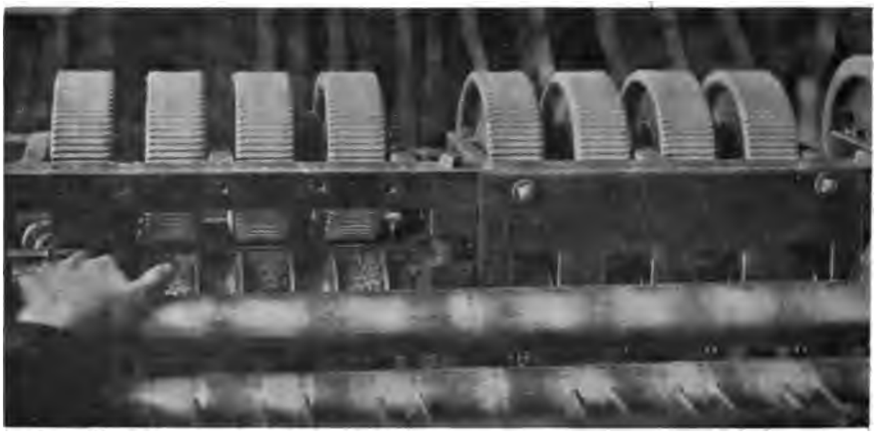


Fig. 3. Guard for Gills of Gunny Roving Frame. The guard has been removed from left-hand section, showing spiked rollers underneath.

Fig. 4. Shuttle Guard for Loom.

This provision is an important one, not only in preventing the opening of gear covers while the machine is running, but also in preventing the machine's being started while a mechanic is at work on the gears with guards removed, — a fairly frequent cause of injury.

A simple and effective type of finger guard for spiked rollers is illustrated in Fig. 3.

Fig. 4 shows a shuttle guard, some form of which should be provided for all looms. The guard should be placed as low as practicable, since accidents sometimes occur from shuttles flying out of looms which are equipped with shuttle guards located too high to be effective.

Fig. 1. Back view of Mule Head with Guards for Gears, Shafting, Pulleys, etc.

Fig. 2. Faller Guard.

Fig. 3. Guard for Sheave, etc.

Fig. 4. **Fig. 5.**

Guarded Rope Sheaves.

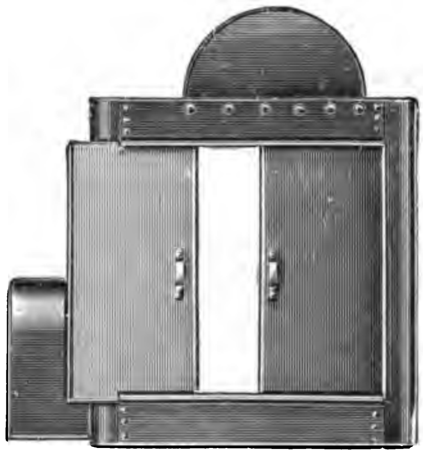


Fig. 6. Mule Headstock Guard.

Fig. 7. Faller Stop Guard. (Pat.)

Fig. 8.

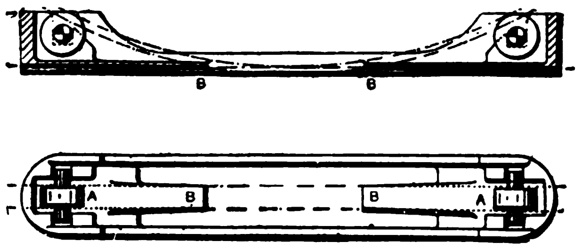


Fig. 9.

Mule Carriage Wheel Guard.

by a competent person who shall certify the safe working pressure for the kier for the next twenty-six months.

Each (closed) kier is to have attached to it a proper safety valve, steam gage, and reducing valve or other suitable means for preventing the maximum pressure being exceeded.

Open Winces (i.e., those having openings more than 2″ wide), are not to be used for cloth in rope form.

Finishing Departments and Calico Printing

Drying cans are to be fitted with a proper reducing valve, and with a proper safety valve and steam gage between the reducing valve and cans. All cylinders, valves and gages are to be examined periodically by a competent person. New, second-hand, or repaired cans are to be tested before being used to at least one and one-half times the normal working pressure.

Ageing boxes, if more than 10′ long should have at least two exits. (Not a part of the British regulations.)

Dye Houses

Centrifugal extractors are to be covered. (See Chapter 35.)

Doors of yarn drying ovens are to be so constructed as to be readily opened from the inside.

Cleaning Machinery in Motion

A child, young person, or woman is not permitted to clean any machinery while it is in motion. The cleaning and polishing of shafts, couplings, and other parts of the transmission equipment is forbidden by the use of waste, rags, emery cloth, or similar materials held in the hand. Automatic traveling cleaners, or other suitable appliances such as padded sticks, brushes, etc., are to be provided for use from the floor level or platforms, where cleaning must be done with the shafting in motion.*

Ventilation

Exhaust heads are specified for singeing machines. Persons engaged about drying machinery are to be shielded from the heat as far as practicable, drying chests and cylinders being provided with exhaust systems, to prevent the escape of steam or hot air in the workroom. Efficient means are to be provided and used for the removal of steam from dye houses. The temperature and humidity of the workroom is not to be unduly increased, wet bulb reading of 80° F. being adopted (tentatively) as a maximum.

* Provisions of this sort are especially important for cleaning drying cans. The practice of cleaning these by hand while the machine is running has caused many bad accidents and should be prohibited.

CHAPTER 32

LEATHER AND SHOE INDUSTRIES

LEATHER INDUSTRY

VARIOUS types of hazardous machines are used in the leather industry. Among these the following are worthy of special mention: —

Tanning Mills usually offer a decided hazard while they are being filled or emptied. The unexpected starting of the mill at this time may result in the death or serious injury of the workman.

The belt shifter should be provided with a positive lock to avoid any possibility of the belt creeping from loose to tight pulley and thus starting the machine. There is still, however, a possibility of the loose pulley "seizing," from lack of lubrication or other cause, and turning the wheel over. To guard against this a positive mechanical stop should be provided. In some cases a chain or anchor has been installed which can be hooked to the wheel whenever it is shut down. There is danger of the chain breaking, however, if the mill is started accidentally; furthermore it requires attention from the operator each time the machine is stopped or started, and an arrangement which can be interlocked with the belt shifter, or otherwise made automatic, is much to be preferred. Individual motor drives overcome the difficulty satisfactorily (see Fig. 2, P. 298), since this form of drive permits power to be cut off completely from the wheel before any work is done about it.

If an anchor or mechanical stop is used it should be of rugged construction and of such strength that there can be no doubt of its ability to hold the wheel in case it starts accidentally.

Unless a positive stop is used, care must be exercised in emptying the wheel to avoid unbalancing the material in such a way that its weight will turn the wheel part way over.

Embossing Machines have been responsible for many serious accidents. Methods for preventing such accidents are shown in Figs. 3 and 4, P. 299.

Glazing and Shaving Machine Guards are illustrated in Figs. 1 and 2, P. 299.

For Rolling, Skiving, Splitting Machines, etc., it is usually possible to provide a fixed guard which will prevent danger of fingers being carried into the rolls or knives. (See Fig. 5, P. 301, and Figs. 1, 3, and 4, P. 298.) Such guards preferably should be arranged so that the opening underneath or through them is not more than $\frac{3}{8}''$. Where this distance does not give sufficient room for satisfactory operation, it must, or course, be increased, but the clearance should be as small as practicable. The skiving machine shown in Fig. 4, P. 298, has a guard with a narrow opening inside the original guide (which is swung downward in the picture); this may be used satisfactorily where thin leather is handled.

SHOE INDUSTRY

The common types of accidents on special shoe machinery are well indicated by the following analysis of 274 accidents reported to one insurance company over a period of about two and one half years. (See P. 300.)

It will be noted that approximately one-third of these accidents caused no lost time; about one-half involved less than two weeks, and a little less than one-fourth involved more than two weeks, lost time.

Beam Cutters and Clicking Machines

Beam Cutters caused the largest number of serious accidents in any one class. Accidents on these machines are usually caused by operators getting their fingers caught between the beam and the die. The hazard from this source may be largely reduced by the following pre-

Fig. 1. Strap Cutting Machine with Guarded Knives, Gears and Pulleys.*

Fig. 2. Tanning Mill, driven by Individual Motor.

The use of individual motor drive is an excellent safety provision for a tanning mill. This practically eliminates danger of the wheel starting up while it is being filled or emptied, as may occur where the wheel is belted direct from line shaft.

Fig. 3. Strap Creasing Machine with Guarded Rolls, Gearing, etc.*

Fig. 4. Skiving Machine with Rolls and Belt thoroughly protected.*

* Courtesy of Eastman Kodak Company.

Fig. 1. Guards for Shaving Machine.*

Fig. 2. Guards for Glazing Jack.*

The curved pieces at either side of cylinder hood in Fig. 1 prevent operator's hands being drawn into revolving cylinder from the sides. The bar over bolster offers similar protection at the top. A rotary, self-locking belt shifter affords a positive safeguard against the machine being started accidentally.

The glazing jacks shown in Fig. 2 have a U-shaped guard around the moving arm of the machine, which is adjustable, but cannot be raised more than $1\frac{1}{4}''$ from the table.

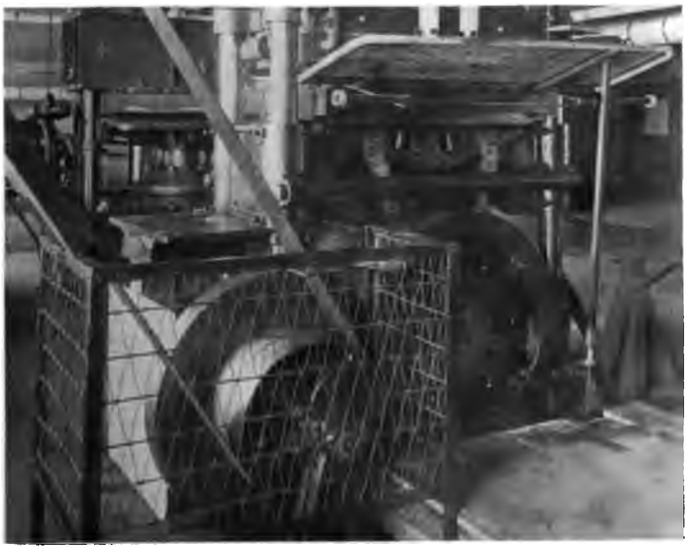


Fig. 3. Embossing Machine Table Guard.*

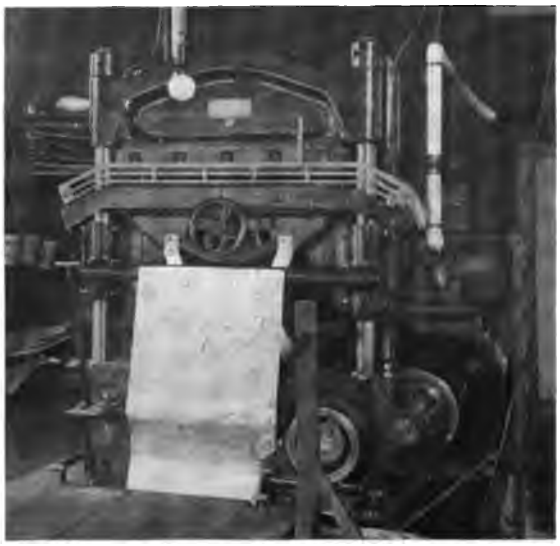


Fig. 4. Guard for Embossing Press.*

The machine illustrated in Fig. 3 is operated by a hand lever connected to treadle at lower right-hand corner of machine, the operator being on the opposite side. This treadle is attached to the table by a vertical rod. Throwing in the clutch to operate the machine raises the treadle, thus elevating the table and warning the feeder, whose arms rest upon it.

A perforated guard in front of the press plates on both sides of the machine shown in Fig. 4, leaves sufficient clearance to insert the leather but will not permit a hand to enter the plates. On the "take away" side, the employee cannot remove the leather until it protrudes from underneath the guard.

* Courtesy of Pfister and Vogel Leather Company.

Type of Accident	A*	B*	C*	Total
Hand slipped against Cutter, Sand Paper Roll, etc., total	*25*	*45*	*6*	*76*
Of these skiving machines caused	3	8	4	15
trimming machines caused	9	19	0	28
Hands caught under Punches, total	*18*	*15*	*5*	*38*
Of these eyeletting machines caused	10	11	2	23
Hands caught on or under Dies, total	*5*	*11*	*15*	*31*
Of these clicking machines caused	2	0	0	2
beam cutters caused	3	11	15	29
Machine started accidentally	*3*	*13*	*11*	*27*
Machine repeated	*5*	*10*	*8*	*23*
Rolls, total	*7*	*8*	*5*	*20*
Of these rolling machines caused	5	3	1	9
skiving machines caused	1	2	2	5
splitting machines caused	0	2	2	4
Caught while operating	*3*	*11*	*4*	*18*
Staples, Nails, etc., in Fingers, total	*5*	*7*	*0*	*12*
Of these staple machines caused	5	6	0	11
Gears, total	*7*	*2*	*2*	*11*
Of these grading machines caused	2	1	0	3
Guards out of Place	*2*	*1*	*2*	*5*
Cleaning while Machine was running	*3*	*1*	*0*	*4*
"Fooling"	*1*	*1*	*2*	*4*
Miscellaneous	*2*	*1*	*2*	*5*
Total	86	126	62	274
Per cent of total	31	46	23	

* "A" indicates no time lost; "B," less than two weeks; "C," more than two weeks.

cautions, No. 1 being alternative with Nos. 2, and 3:—

(1) *A traveling Carriage* may be used for holding the die, thus doing away with the intermittent contact between die and beam, which is one of the principal causes of accidents. (See Fig. 1, P. 301.)

(2) *Safety dies* should be used. By "safety dies" is meant (*a*) those having a protective flange around the top of the die, or grooves in the side of the die into which the fingers of the operator fit or, (*b*) dies of "handle" type with a disc or button at the top of the handle to prevent operators' thumbs being placed over the end of the handle and crushed by the beam. (See Fig. 2, P. 301.) Dies of "Walker" type should be of adequate height (preferably not less than 3½") to permit free use of the hands on the die, and to prevent hands being jammed between beam and block.

(3) *Positive Non-Repeating Devices* should be provided for beam cutters. In this respect the condition is similar to that described in Chapter 20 for punch presses; as beam cutters are commonly arranged, unless the operator removes his foot quickly after the first stroke is taken, a second stroke will result. This is likely to catch him unawares and result in an injury.

In fifteen accidents out of a total of twenty-nine shown in the above list as occurring on beam cutters, the operator claimed that the machine *repeated*. While this claim may be made in some cases where repeating was not the real cause of the accident, there is no doubt but that this is a genuine and frequent source of injury on beam cutters. The hazard has been recognized by some of the standard machinery builders, however, and satisfactory non-repeating devices for beam cutters can now be obtained.

A positive mechanical stop should be combined with the non-repeating device, in order to prevent the machine from taking a second stroke on account of the friction being worn or loose. In this respect, also, the beam cutter is similar to the power press.

Clicking Machines, although using metal dies and being somewhat similar in action to beam cutters, are inherently safer than the latter. This is indicated by the fact that only two accidents in the above list occurred on clicking machines (and these were both minor in character), although many such machines were used in the plants represented.

Finger guards may be applied to these machines, however, as illustrated in Fig. 3, P. 301, which practically eliminate all operating hazard.

Rolling, skiving and splitting machines caused a considerable percentage of the above accidents. These machines are similar to those already mentioned in connection with the leather industry and similar safeguards apply. (See Fig. 5, P. 301, and Figs. 1, 3, and 4, P. 298.)

The other accidents included in the above list require little further comment. In many cases it is possible to provide a guard which will completely, or at least partially, protect the

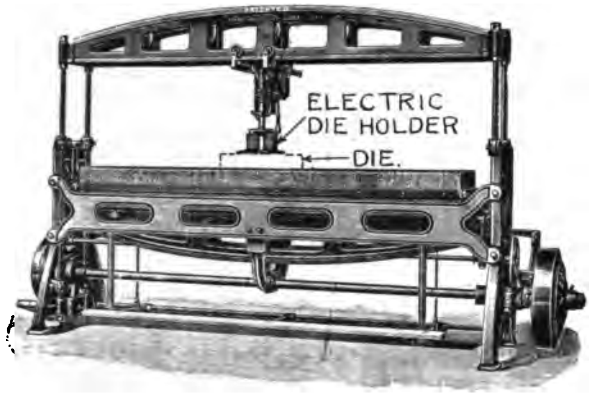


Fig. 1. Beam Cutter equipped with Electric Die Holder on Traveling Carriage. (Pat.)

Fig. 2. Types of Safety Dies.

Fig. 3. Clicking Machine equipped with Finger Guard.*

Fig. 1 shows a good arrangement for preventing accidents on beam cutters. With this die holder, which is constantly in contact with the die, the beam does not strike the top of the die; danger of fingers being caught between die and beam, is thus eliminated.

The guard shown in Fig. 3 prevents operator from getting fingers under platen and having them crushed when the machine operates.

The guard indicated by arrow in Fig. 4 prevents finger from going under knife.

Fig. 5 shows good forms of roll and gear guards; note also switch enclosure on post.

Fig. 4. Finger Guard for Rand Trimming Machine.

Fig. 5. Protected Flattening Rolls.†

* Courtesy of Eastman Kodak Company.

† Westinghouse Electric and Manufacturing Company.

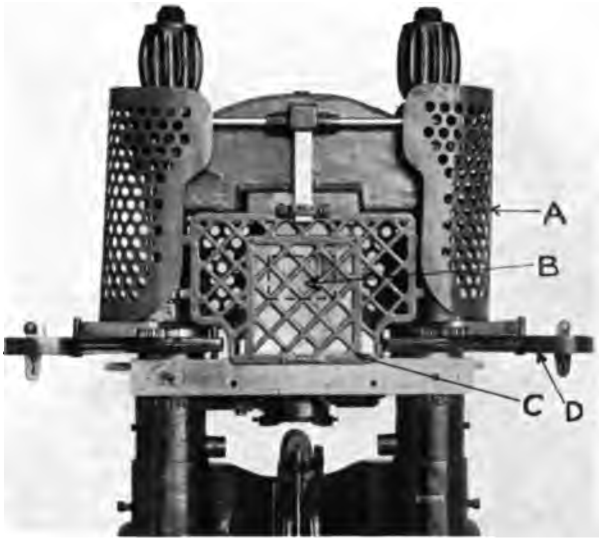


Fig. 1. Guards for Lightning Heeler.

Fig. 2. Out-Sole Rapid Stitcher, enclosed.

The guard shown in Fig. 2 encloses a mass of moving parts, preventing accidental contact with them and at the same time relieving the operator's eyes from the strain and confusing effect of the moving parts. Fig. 1 shows shields (A) to protect crushing action between the guides and driving head which raises and lowers. A celluloid shield (indicated by dotted lines at B) is fixed in front of the nail drivers, to prevent injuries from breaking drivers. Gate C rises automatically as the nail carriers (D) swing into loading position under driving head, lowering again, as they are removed, to guard the drivers.

Fig. 3. Guard for Tack Puller.

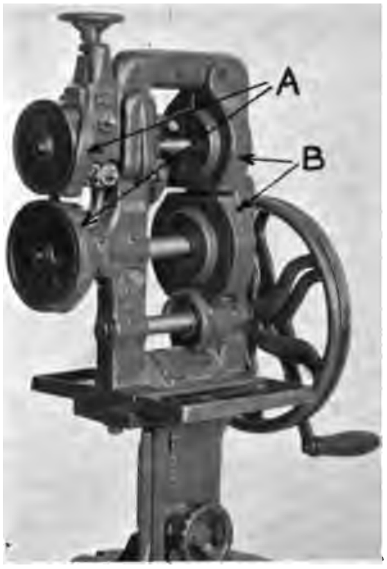


Fig. 4. Protected Channelling Machine.

Fig. 5. Guard for Welt Trimming Machine.

Shield A (Fig. 3) tends to prevent tacks, which are pulled by the revolving head, from rebounding out of hood B; it also protects the head, to a considerable extent. Fig. 4 shows guards to prevent fingers being caught between rolls of channelling machine, the lower roll of which is corrugated. Gear guards are shown at B. In Fig. 5, guard A protects the revolving cutter.

point of operation. (See Fig. 4, P. 301 and Figs. 1 to 5, P. 302.) In this, as in other industries, the removal of guards, cleaning of running machines, and "fooling" about machines appear as causes of accidents.

A type of needle guard, which is an effective device for preventing injuries on stitching machines, is shown in Fig. 3, P. 171.

Volatile Oils (benzine, naphtha, gasolene, etc.) are used in various forms in this industry. As mentioned elsewhere they should only be brought into the factory in small quantities, and should be kept in approved safety cans which will prevent danger of fire and explosion. (See Chapter 45.) Even a slight fire, insignificant in itself, has dangerous possibilities in a shoe factory. Such factories are commonly crowded with operatives, many of whom are women, and a panic which will result in serious loss of life may be started by a small fire.

Cement having benzine, naphtha, etc., as a solvent should be kept in covered storage cans and where necessarily exposed in open vessels for immediate use, only a small quantity should be allowed in each vessel.

Blocking of Fire Escapes in shoe factories, by the trucks and racks which are commonly used in this industry, may prove a serious menace in case of fire or panic.

Superintendents and foremen should be constantly on the look-out to see that aisles and passageways leading to fire escapes are kept reasonably clear at all times. This is also a good subject for the consideration of safety committees, and one which they may follow up to advantage wherever such committees are formed.

Fire Drills are desirable in shoe factories where many persons are employed above the second floor. (See Chapter 41.)

CHAPTER 33

GAS WORKS

THE special hazards of the gas industry are those of fire or explosion, which are more or less constant, and of asphyxiation from the inhalation of gas during emergency work, alterations to equipment, etc. The hazard from these sources can only be avoided by constant care and caution on the part of those working about the plant, combined with an intelligent understanding of the possibilities of danger.

It is suggested that written rules be prepared for each plant, copies of these rules being given to all employees in order that they may be thoroughly familiar with the approved practice for ordinary operation, as well as for emergency or repair work. Signs forbidding the use of matches or open flames, smoking, etc., in certain locations, may also be used to advantage as mentioned later.

One person should not be permitted to work alone in a location where he might be overcome by gas; under such conditions a second person should always be present, ready to render aid in case of emergency. Special precautions should be taken in providing a thorough system of guard rails at floor openings, stairways, etc., where there is a possibility of persons becoming dizzy from the inhalation of gas.

Some valuable work in developing safety rules for the gas industry has been done by the Accident Prevention Committee of the American Gas Institute, Mr. J. B. Douglas, Chairman. (See "Report of Committee on Accident Prevention," October, 1914.) Indebtedness is acknowledged for the use of material prepared by this committee, as indicated in the following pages; also for material from a paper by Mr. W. L. Bruce, Claims Agent of the Westchester Lighting Company, which appeared in "Safety" (March, 1915) published by the American Museum of Safety.

These reports include many precautions of a general nature, which are common to all industries and which are covered in other chapters of this volume; only the portions relating to the special hazard of the gas industry are given here.

Mr. Bruce's paper is, in part, as follows: —

Generator House

It is considered good practice on starting up idle water gas machines to ignite the blast gas at the top of the carburetor during the first blow with a red hot iron, by inserting the iron through the sight cock at the top of the carburetor and admitting secondary air through the carburetor blast valve.

In water gas machines, when starting up after a shut-down (especially when firing up an idle machine), back drafts through the superheater and carburetor may cause an explosion at the generator coaling hole which might burn the operators' faces and hands. This is particularly liable to happen on the first coaling after the first blow after starting a new fire in the generator. Such results may be avoided by carefully opening the generator coaling hole a very little and igniting the gases with a torch, the men standing well away until the gases are burning, when the coaling hole lid may be opened wide for coaling up.

Before opening cleaning doors on lower level, generator coaling lids should always be opened and dead gases in the top of the machine allowed to ignite. This will avoid a probable flashing back at the cleaning doors downstairs, which is apt to burn men's faces.*

When it is necessary to clean the standpipe, the manholes and handholes should always be opened, starting at the top and working down. It is good practice to turn sufficient water into the wash boxes to raise the level to the first door or opening in the standpipe while it is being cleaned, rather than take chances of allowing the hot carbon cleaned from standpipe to fall into the wash box with risk of an explosion from vapors working back from the scrubbers.

After standpipe has been cleaned, and carbon removed through door just above the top of the wash box, the wash box can then safely be emptied and cleaned. It is important to see that the wash box is closed up and resealed before closing doors on standpipe.

Where wash boxes are located on the lower floor, it is considered very good practice to put a stopper in the goose neck of the standpipe during the time the wash box is opened to be cleaned, to avoid any chance of an explosion from the heat of superheater igniting gases in the standpipe.

More care is necessary on standpipes and wash boxes where there is no valve on the outlet of the wash box. Even with such a valve in place, a vent pipe between the gates should be opened.

If water gas machines are shut down for any length of time,

* (Author's note.) It is well to have cleaning doors equipped with safety clamps, which permit a slight opening of the door before releasing it entirely.

Fig. 1. Dangerous Method of Tightening Cotter Bars.*

Fig. 2. Hand Wheel for Cotter Bars.*

Burns or other accidents may be caused by the use of too much power on cotter bars of generator doors, by applying a pipe as shown in Fig. 1, resulting in stripped threads which permit a leak. The removable hand wheel shown in Fig. 2 obviates this hazard.

Fig. 3. Clinker Bar Holder.*

Fig. 4. Guard for Generator Coaling Door.*

Safety tongs for holding clinker bar, also device placed in coaling door of generator to steady bar while being hammered, is shown in Fig. 3.

The guard shown in Fig. 4 prevents objects falling into generator and injuring workmen engaged in making repairs inside the generator.

* Courtesy of the United Gas Improvement Company.

oil sprays should be removed and pipes plugged, to prevent accidental flooding of carburetor with oil.

Flanges of oil meter should be covered by a metal cover to avoid fine sprays of oil (resulting from leak in the gasket) taking fire.

In constructing water gas machines, it is good practice to install what is known as a safety gate in the blast pipe, so that gas, which might possibly leak back through the blast valves, could only explode in a section, thus preventing extensive damage to the greater part of the blast main and to the blower itself.

Iron guards or heavy iron netting should be placed over the safety heads in blast mains, so that in the event of an explosion in the blast main the safety heads are prevented from flying and striking operators.

The Committee on Accident Prevention of the American Gas Institute (hereafter referred to as the "A. G. I. Committee") makes the following additional recommendations for generator house equipment: —

Workmen engaged in clinkering should guard against hot coke dropping in shoes, which should be snugly laced.

Seal pots should be covered or guarded.

Generator coaling doors should be securely fastened.

No naked lights or flame should be allowed near wash box.

Oil lines should be provided with cut-offs outside of building.

(See also P. 305.)

Hot Scrubbers and Shaving Scrubbers

In opening up scrubbers for inspection or repairs to trays, it is essential after the gas has been properly shut off, to be sure that the top manhole of the scrubber is open before the bottom manhole, and that no naked flames of any kind be brought anywhere near the scrubber while the manholes are open.

Relief Holder

Oil must not be allowed to accumulate on the outside surface of the water in the relief holder tank, neither should any naked flames be used anywhere near the relief holder.

P. & A. Tar Extractor or Condenser

Naked flames should not be used around overflows of P. & A. Condensers and Tar Extractor.

Purifying House

No loose matches should be carried in the pockets or about the persons of those who, for any reason, enter the purifying house. No gas jets or naked flames of any description should be permitted in the purifying house. Electric lights used for lighting purifier houses should be protected with vapor-proof outer globes.*

Care should be exercised in shutting off and turning on purifying boxes,— (1) that all air is blown from new purifying boxes before being brought into use; and (2) that purifying boxes are properly vented (by opening vent caps) before being opened, and that center seal (if one is in use) or that all valves (in case the box should be controlled by valve system) are absolutely tight after boxes have been vented and before covers are raised.

Before raising covers of purifying boxes, *all* windows of purifying house should be opened for ventilation, in order to furnish fresh air for the men cleaning boxes.

The oxide being removed from boxes, especially if it is new material, should be watched closely to keep it from taking fire, as there is not only danger of destroying the material but also of having a disastrous fire or explosion in case the purifying material should become hot enough to ignite the trays or other woodwork of purifying house.†

Purifying boxes should not be vented or covers raised until such time as all arrangements have been made for emptying oxide.

In case it is the practice to revivify oxide without taking it out of the box, it should be watched closely to prevent the material taking fire.‡

Seals of purifying boxes should be inspected daily and kept full of water.

Pipe connections from a hydrant should be brought to the edge of the purifying boxes, with valve control near the door of the purifying house on the floor where the boxes are located; if the valves are not on the same floor as the boxes, they should be plainly labeled to show to which box each water pipe runs. These water pipes and valves will eliminate the dangerous practice of sending a man into the purifying house to reseal a purifying box in case the seal should blow, as with the valves near the door the possibility of his asphyxiation is minimized.

The A. G. I. Committee makes the following additional recommendations for purifying house equipment: —

If gas wall lights are used, recesses should be hermetically sealed from the inside of the building.

Cleaning of purifier boxes should not be done by less than two men.

Guards should be placed on wheels of box-lid carriers.

On doors and entrances to purifier house, signs reading as follows should be hung "Danger, No Smoking, Keep Fire Away."

Retort House

The A. G. I. Committee makes the following recommendations for retort houses: —

Charging and discharging machines should be equipped with automatic terminal stops, and also bells or whistles to automatically give notice of change of position.

Wheel guards should be provided to avoid foot injuries.

Cotter pins and nuts on buggy axles should be frequently examined.

Fire tools and bars should be kept in racks when not in use, and not left on floors or leaning against walls.

Boiler House

Tar or oil should not be thrown into the boiler from a pail or shovel. If it is necessary to burn tar or oil along with the coal, it should be sprayed in with tar burners, or mixed with the coal on the floor and the mixture thrown into the boiler.

Meter House

Station meter water levels should be inspected at least every six hours, if there is a continuous water feed to the meter, to be sure that the overflow is working properly. An abnormal rise in the water level will cause back pressure on the purifiers, resulting in the blowing of the seals, with consequent danger of explosion and fire if the gas should become ignited.

* (Author's note.) Switches, cut-outs, etc., should also be of approved enclosed type or located outside the building; wiring should be of approved rubber-covered type with soldered connections; keyless sockets should be used. (See National Electrical Code.)

†(Author's note.) In new purifying houses it is recommended that woodwork be eliminated entirely, only non-combustible material being used. In present buildings any woodwork which may come in contact with the oxide should be covered with sheet metal or otherwise protected. Hose streams should be available, when boxes are opened, for use in case the oxide should take fire. At least two means of exit should be provided from the operating floor.

‡(Author's note.) It is desirable, wherever practicable, to remove the oxide to a separate room shut off from purifying room by means of a fire door.

Holders and Tanks

Steps, platforms, ladders and walk-arounds on all holders should be kept entirely free of ice during the winter to avoid the danger of a man slipping and falling. All steps, ladders, platforms and walk-arounds on holders should be provided with adequate railing equipment. (See Chapter 10.)

The A. G. I. Committee makes the following additional recommendations for Holders and Tanks: —

Stairways and platforms to holders should have intermediate rails and not a single rail only. There should also be an intermediate rail on galleries in front of siphons. (In adjusting the siphons the operator is usually in a stooping position, and his body is below a single handrail guard.)

Straight ladders to holders should be provided with cage guards. (See P. 233.)

When stairways to holders are accessible to public, they should be guarded by gate and screens.

Holder pits should also be guarded.

Roofs and hatch covers of tanks should be made of substantial material. Open tanks should be provided with floats and life lines.

Gas and oil tanks should be carefully purged before being entered. As an extra precaution, workmen entering tanks should wear life lines, held by others outside the tanks. (See Fig. 3, P. 277.)

Governors

All valves on gas main between storage holder and outlet to the distribution system should be diagrammed, and a sketch placed in the governor room or some other convenient building, as a guide in connection with the handling of gas supply to the distribution system in case of trouble. Such valves should not be operated except in the presence of the superintendent, foreman or some other authorized person.

Street Work

A tapping machine should not be removed from gas pipe, thus leaving an exposed hole open to blowing gas unless, in addition to the man in the trench, there is also a man on the bank watching.

In cutting in fittings and making connections with mains, where it is necessary to bag off both sides of the cut, there are two important points to be guarded against: First, that no men are overcome by gas; second, that the gas pressure is maintained.

The only sure way of ascertaining whether the pressure is being maintained, is through the use of "U" gauges, one on each side of the cut, during the process of the work.

One way to keep the trench free from gas is to use a stopper in one tap hole and a bag in another tap hole (about 2′ apart) with a vent pipe between them. This vent pipe should extend to a height of at least 8′ above the street surface so that any gas leaking past the stopper will be carried well away from the trench and from the men working on the main.

Plugs must be used in service tees to shut off the gas from the service until such time as the service is either made up to the curb valve which is shut, or to the cock placed on the inside of the foundation wall on the service pipe.

No services from pumping or transmission mains carrying more than ordinary distribution pressure (6″), are to be opened up inside of cellars for any purpose whatever, unless the curb valve or cock on the inside of wall has been previously closed.

No lighted candles, lanterns, lamps or matches should be used in opening street manholes, in, or in the vicinity of, manholes of gas, water, electric and telephone companies, especially where gas leaks are being looked for or are known to exist. (For method of ventilating manholes see Fig. 1, P. 277.)

No picks or bars should be used to lift these covers, but hooks should be used in all cases, care being exercised to guard against striking sparks which have been known to ignite explosive mixtures inside of manholes with resulting explosion.

In barring for leaks, care should be exercised that the bar does not in any way touch the cables in electric and telephone conduits, as serious interruptions have been caused on trunk lines of other companies by Gas Company's bars being driven through these cables.

All tool carts and tool boxes on wheels should be equipped with bar locking device to prevent them from being moved, stolen or used for see-saws by children.

Miscellaneous

In cold climates, the contents of the tank drip in wagons and barrels is apt to freeze when being brought in from the district. Great care should be exercised in thawing out the drain cocks or connections to these drip tanks and barrels. No red hot irons or fire of any kind is to be used for this purpose. Steam is recommended in all cases.

Proper skids with iron hooks on the end should be provided for loading pipe on, and unloading pipe from, wagons and railroad cars. If such equipment is not provided, planks will probably be used. These will easily slip off the wagons or cars, with serious results if pipe is on them at the time.

In hilly districts, drag shoes with chains should be provided for use on heavily loaded wagons where it is necessary to go down a steep grade.

Red flags should be provided on the back of all wagons from which material projects such as long ladders, pipe and lumber. These flags should be kept in place at all times while such material is on the wagon.

Respirators and Goggles are recommended for use in cleaning out combustion chambers, smoke boxes, or working in an atmosphere heavily charged with dust. Goggles should also be worn while chipping metal or scale, bulling standpipes, or other work where there is danger of foreign matter getting into eyes. (See Chapter 48.)

Rescue or Breathing Apparatus

It is very desirable to have suitable rescue apparatus available at each gas plant. Conditions may arise at any time which will make it necessary to work in a gaseous atmosphere, which can be done safely with the proper equipment but which may be very hazardous without it.

Emergency work of this kind does not continue for such length of time as to make necessary the heavy apparatus used in mine rescue work. (See Fig. 4, P. 253.) Light equipment, one type of which weighs only about six pounds, is relatively inexpensive and is satisfactory for thirty minutes' continuous service without recharging, will meet the need in gas works. (See Fig. 2, P. 308.)

For certain kinds of work such as tapping street mains, entering tanks, etc., the use of a fresh air helmet with hose connection and bellows, as illustrated in Fig. 2, P. 277, is suggested.

For the benefit of men who have been over-

Fig. 1. Guards for Truck-Wheels of Charging Machines.*

Fig. 2. Oxygen Breathing Outfit.

Serious accidents have been caused by employees being caught beneath wheels of charging machines. A good method for guarding these wheels is shown in Fig. 1.

A light form of breathing apparatus, which can be put on in a few seconds, is shown in Fig. 2. It weighs only about six pounds, and will permit continuous work for thirty minutes in a gaseous atmosphere without recharging. It is particularly adapted to gas works, refrigerating plants, etc.

Fig. 3. Guards over Tar Separator Wells.*

Fig. 4. Portable Barricade for Street Work.*

Fig. 3 shows where a man was injured by falling into a tar separator well and being scalded. Both wells have since been guarded, as illustrated in the photograph.

* Courtesy of the United Gas Improvement Company.

come by gas, or subjected to gas poisoning, it is desirable to have a supply of oxygen available. A good type of oxygen equipment for this purpose is shown in Fig. 5, P. 293.

Employees should be trained in proper methods of resuscitation, so there will be no delay in taking prompt and effective action in case of need. (See Chapter 51.)

"*Housekeeping,*" *piling and storage of material, the use of hammering tools* and other subjects of interest in the gas industry are covered in separate chapters of this volume.

CHAPTER 34

CONTRACTING

CONTRACTING is generally considered a hazardous industry, and accident statistics support this impression: 97, or slightly more than 20% of the total of 474 fatal accidents occurring in Massachusetts during one year, were in the contracting industries ("Building and Hand Trades," and "Construction and Maintenance of Streets, Roads, Sewers, Bridges, etc.," see First Annual Report of the Industrial Accident Board).*

Falls	*31*
From Scaffolding	11
From Permanent Structures	2
From (or with) Portable Ladders	2
Miscellaneous	16
Struck by Vehicles	*22*
Animal-drawn	8
Railroad Car or Locomotive	6
Street Railway Car	6
Automobile	2
Excavating, — cave-in	*13*
Hand Labor	*7*
Caught by Material	5
Struck by Tools	1
Strains	1
Material Falling from Overhead	*2*
Elevators	*4*
Cranes and Hoists	*5*
Gears	*2*
Electric Shock	*4*
Asphyxiation, Drowning, etc.	*3*
Infection	*1*
Animals or Insects (bite, kick, or sting)	*3*
Total	*97*

SUPERINTENDENCE

On account of the constantly changing conditions which are encountered in contracting work, superintendence is probably a more vital factor in this industry than any other. Dangerous conditions may arise from day to day, or even from hour to hour, which may be detected and eliminated by the careful superintendent and foreman, but which will inevitably cause accidents if not remedied.

The above list of accidents indicates very clearly, however, that there is much room for mechanical safeguards in the prevention of contracting accidents. Eleven fatalities, or more than 10% of the total, were on mechanical equipment. In fact the only two fatal gear accidents which occurred in the State during the year were in the contracting industry.

Taking up the above hazards in detail the following points are worthy of comment: —

Falls

Many of the falls included in this list occurred from the lack of protection at openings in floor or ground, at exposed edges of platforms, etc. Such protection is frequently omitted in contracting work on account of the fact that it must be temporary in character. The general unsettled conditions where work of this kind is going on, the handling of unwieldy material, etc., make the hazard from falls even greater, if anything, than in factories operating under ordinary conditions; it is accordingly equally important from the safety standpoint to provide standard railings or other suitable barriers (approximately 3′ 6″ in height) at all exposed edges or openings where falls may occur.

Where conditions are such that persons below might be injured by material falling from the exposed edge, a toe-board at least 6″ in height should be provided, or better still the space between the railing and floor or ground level should be filled in with woven-wire fabric, boards, or other suitable material. This applies to stairway shafts, elevator or hoistway openings, balconies, bridges, excavations, etc.

* During this period there were 9,753 non-fatal accidents in the contracting industries, or about 11% of all accidents occurring in the State.

In the construction of steel buildings it is important to follow the erection of the steel work as rapidly as possible with the provision of flooring, either permanent or temporary. The building Code recommended by the National Board of Fire Underwriters calls for fireproof floor construction within two complete tiers of the steel framing during erection. Where brick or other fireproof material is not required between the floor beams, it specifies that the under-flooring, or other planking, shall be laid in each story as the building progresses; where the floor construction is structural steel, thorough planking of the entire tier of steel beams on which the structural steel work is being erected (excepting reasonable space for hoisting materials and other erection work) is required. (See Sec. 264 of the Code.)

For a discussion of methods for preventing accidents from ladders and scaffolding, see Chapter 24.

Vehicles

More than 20% of all fatalities in the above list were caused by vehicles, indicating the seriousness of this hazard in the contracting business.

Warning signs, lights, flagmen, temporary barriers, etc., may be used to reduce this hazard. Where men are to work directly in line of traffic, it is very important to have definite rules prepared beforehand, for their guidance. It should be ascertained that the workmen understand these rules or instructions before starting to work in a dangerous position.

Many accidents to foreign laborers, who understand the English language slightly or not at all, have resulted from ignorance of the dangers involved. Such workmen should be instructed in their own tongue if necessary.

Excavating, etc.

This is a cause of frequent accidents in contracting work. Wherever there is any possibility of a bank caving in, it should be substantially shored up in such a manner as to obviate danger. For such work steel sheet piling is preferable to wood, on account of its greater strength and homogeneity.

In working on material piles, such as coal, sand, gravel, ore, etc., workmen may be caught by falling material. Fatal accidents have resulted in piles so low that the hazard would not be realized ordinarily. (See Fig. 1.)

Fig. 1. Scene of Fatal Accident from Cave-In.

A workman could almost reach to the top of this ore pile and the hazard would appear to be slight; yet a quantity of falling material caught, and caused the death of, a man who was loading a wheelbarrow from the pile.

The workmen should be instructed as to the proper slope to be maintained in a given material. In some cases a safety rope and belt (see Fig. 3, Page 277) may be used to good advantage.

Hand Labor

Fatal accidents resulting from hand labor depend almost entirely on personal care and watchfulness for their elimination.

Many additional accidents, eye injuries, etc., which, although not fatal, are nevertheless serious in character, result from particles flying from hammering tools, indicating the necessity for keeping such tools properly dressed. (See Chapter 21.)

Material Falling from Overhead

Accidents from this cause may be guarded against both by personal care on the part of the workmen and by the construction of barriers, temporary flooring, etc., as already mentioned under "Falls."

Where new buildings are being erected, building walls increased in height, etc., a substantial shed should be erected over sidewalks or commonly used passageways adjacent to the building, if the latter is, say, more than forty feet, in height.

Elevators

The enclosure of elevator shafts, of unused sides of the elevator car, provision of safety clamps on the car proper and automatic stops at the upper limit of travel, are important safety precautions for contractor's elevators. (See Chapter 19.) An effective signaling system is also desirable for elevators and hoists, particularly where they are controlled from an engine or motor located at some distance from the equipment driven.

Cranes and Hoists

Hoisting equipment should be regularly inspected to see that it is kept in good condition at all times. Care should be taken to avoid overloading chains or ropes. (See Chapter 25.)

Gears

All gearing, belting, shafting, etc., should be enclosed or guarded in accordance with general mechanical standards. (See Chapters 17 and 18.) This protection should be applied to gears of hand-operated cranes and hoists, since the load may run down by gravity making the gears virtually power-driven.

Electric Shock

Two methods are available for avoiding serious results from electric shock in contracting work: (1) Temporary railings or enclosures should be provided wherever necessary to prevent accidental contact with dangerous electric wiring or other apparatus. (See Chapter 13.)

(2) Wherever there is exposure to the electrical hazard, one or more employees should be trained in the proper method of resuscitation from electric shock. (For a description of this method, see P. 391.)

Asphyxiation, Drowning, etc.

Where exposed to gases or vapors which may cause suffocation, the workmen should be instructed regarding the danger and where necessary, suitable breathing or rescue apparatus should be provided. (See Fig. 2, Page 277, and Fig. 2, Page 308.)

It is also important where asphyxiation or drowning may occur, to have employees trained in the proper method of resuscitation as mentioned for "Electric Shock."

Infection

The nature of contracting work is such that minor cuts and abrasions are of relatively frequent occurrence. Suitable first aid equipment should be kept at each job and all such injuries, even though slight in character, should be antiseptically treated. For this purpose 3% alcoholic iodine gives excellent results. (See Chapter 50.) Prompt serum treatment of men receiving nail punctures may be desirable, to prevent danger of lock-jaw developing.

Housekeeping

In contracting work especially, good "housekeeping" is of vital importance. Many injuries result from nail punctures and from falls over tools and materials. This may be minimized by general care and orderliness in all branches of the work. (See Chapter 49.)

Explosives

Where explosives are used, constant care and watchfulness in their handling and storage are necessary to avoid serious accidents. (See Chapter 42.)

Tunnel and Caisson Work is a specialized line of contracting that will not be discussed in detail here. Those interested in safety precautions for such operations are referred to a booklet issued by the New York State Department of Labor entitled, "Laws and Regulations Relating to Mines, Quarries, and Tunnels."

Eye Protection and Various Other Subjects which are of more or less interest in contracting work are discussed in other chapters of this volume.

CHAPTER 35

LAUNDRIES

OWING to the fact that girls constitute a considerable percentage of most laundry employees, special precautions should be taken for the protection of laundry equipment. All gearing, belting, couplings, set screws, chains, sprockets, shafting, etc., should be thoroughly guarded, in accordance with the standards, given in Chapters 15 and 17. Locking belt shifters should be provided for all belt-driven machinery, as mentioned in Chapter 17.

In addition to the common mechanical safeguards, there are a number of precautions which should be taken to reduce the special hazard of this particular industry.

Centrifugal Extractors. (See Page 314.)

Many serious accidents have occurred from persons getting hands or arms caught by the material in revolving centrifugal extractors; in some cases this has resulted in broken arms or wrists, and in others men have had their arms completely torn off.

All extractors should be equipped with covers, hinged or otherwise attached to the machine so they cannot be completely removed. These covers should interlock with the starting mechanism in such a way that the cover cannot be opened while the basket is revolving and the machine cannot be started without the cover in place. Unless this interlocking arrangement is provided, the hazard is not entirely eliminated by merely providing a cover, since the employees are liable to raise this cover and reach into the machine before it has stopped revolving. The momentum of moving parts is sufficient to keep the basket turning for some time after the power has been shut off, and many accidents have occurred from persons attempting to use the hand as a brake to stop the basket.

Ironers. (See Pages 315 and 316.)

Several types of ironers are used in laundries, usually consisting of various combinations of rolls. Operatives are liable to have their hands caught between these rolls, or carried into them by the material which is being ironed. Flat-work ironers should be provided with a guard in front of the rolls on the feeding side, preferably arranged so that it will shut down the machine automatically if an operative's hand comes in contact with the guard.

The rolls should also be guarded over the top and at the sides, so as to make it impossible for an operator to reach them while the machine is running. This may be accomplished in some types of ironers by having screens or guards over the rolls interlocked with the starting device, as mentioned above for centrifugal extractors. Where the arrangement is such that the operatives can reach over the side to remove pieces which have become wrapped around the rolls, a guard or fence should be placed at the side of the machine, and a rule should be enforced that the machine must be shut down before this guard is removed.

Other types of machines, bosom ironers, collar and cuff ironers or dampeners, etc., should have an automatic stopping device, or an idle roller or fixed guard in front of the rolls located in such a position as to prevent fingers or hands from entering the rolls.

Explosion Hazard of Flat-Work Ironers

Where flat-work ironers have steam-heated cylinders, there is a possibility of these cylinders exploding; serious accidents have occurred from this cause.

If these cylinders are intended to operate at a lower pressure than that carried by the boiler supplying them, a reducing valve should be

Fig. 1. Centrifugal Extractor with Cover.

Fig. 2. Extractor with Cover and Latch for Belt Shifter.

The latter consists of a flat steel bar (which will be noted overhead) with an off-set portion which engages the shifter-lever and holds it securely in place when the machine is stopped.

Fig. 3. Centrifugal Extractor with Safety Cover.

This cover interlocks with the driving mechanism in such a way that the cover cannot be lifted while the machine is running, and the machine cannot be started without the cover in place.

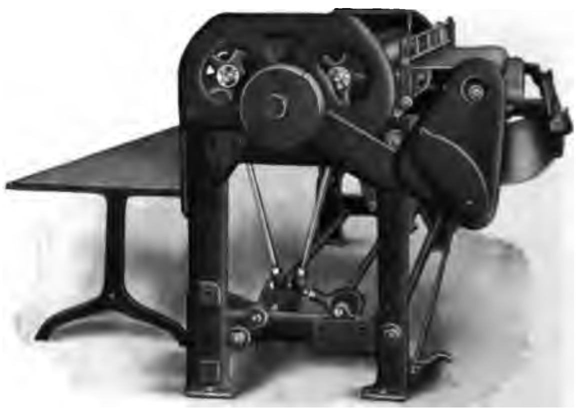


Fig. 4. Flat-Work Ironer equipped with Ribbon Feed, Belt and Gear Guards, and Automatic Safety Stop.

This stop is operated by the guard across the front of the rolls, stopping the machine if a hand comes in contact with the guard.

Fig. 1. Flat-Work Ironer with Automatic Stop.

If a hand comes in contact with the guard in front of the feed rolls, the machine stops immediately. Note also ventilating hood over ironer.

Fig. 3. Flat-Work Ironer with Interlocking Guard.

This machine has a bar in front of the feed roll, connected to a woven wire guard over top of the rolls. This guard prevents an operator from reaching between the rolls to remove goods. The guard is interlocked with the starting mechanism so that the cover cannot be lifted while the machine is running and the machine cannot be started until the cover is in place. The ribbon feed with which these machines are equipped is, in itself, an excellent safeguard.

Fig. 2. Flat-Work Ironer with Guard over Rolls.

This guard prevents the operators from attempting to remove articles from the rolls while they are moving. The guard is ordinarily locked in position, but it is provided with counterweights so it can be readily raised when necessary. The key is kept by the foreman, or other designated authority.

Fig. 4. Steam Cylinder of Flat-Work Ironer which Burst, Wrecking Building.

Serious accidents have been caused by the explosion of flat-work ironer cylinders. An examination of the cylinder shown in Fig. 4 showed poor material and improper workmanship. The $\frac{3}{4}''$ bolts were badly crystallized, specimens breaking in two when one end was held in a vise and the other struck with a hammer. The holes in cylinder and cover were improperly aligned, and as the bolts had conical bearing surfaces, this caused a bending action as the bolt was seated with the wrench. Several of the bolts had broken entirely before the accident occurred and others showed progressive fractures.

Fig. 1. Sleeve and Body Ironer equipped with Guard and Ventilating Hood.

This guard is interlocked with the starting mechanism so that if a hand comes in contact with the guard the machine is instantly stopped.

Fig. 2. Fixed Guard for Sleeve and Body Ironer.

This guard is fastened rigidly in position; it is so located as to prevent danger of a hand entering the rolls.

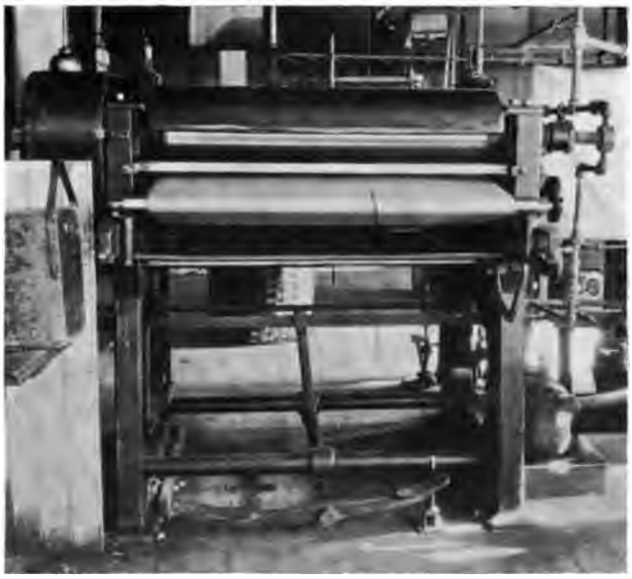


Fig. 3. Collar and Cuff Ironer with Fixed Guard for Rolls, Gear Guards, Heat Deflector and Treadle Latch.

This machine has been equipped with a treadle-lock, consisting of a short vertical bar or latch fastened to floor underneath treadle. A notch in the bar engages the treadle, the latch being held forward by a flat spring. It can be readily released, however, by pressure of the toe, when it is desired to start the machine.

Fig. 4. Collar and Cuff Ironer. This is equipped with finger guard and with a good arrangement of gear covers.

used, a safety valve and steam gage being placed on the low pressure side of the reducing valve. The safety valve should be tested at regular intervals, and the steam gage should be observed frequently to make sure that the reducing valve is properly limiting the pressure.

Care should be taken in warming up these cylinders, to minimize the stresses resulting from expansion and contraction. To this end it is recommended that the cylinder be started to revolve as soon as steam is turned into it. The drains should be arranged so as to remove the water of condensation as thoroughly as possible, and the drip should be left open until the cylinder is entirely heated, in order to prevent water from accumulating in the bottom of the cylinder and causing unequal expansion.

Experience has shown that the alternate heating and cooling of these cylinders is liable to start progressive fractures in the bolts, which may cause them to break successively and finally result in the head of the cylinder being blown off. Some of the bolts should be removed at intervals of four or five years and tested, and if they show signs of deterioration they should all be replaced.

Bolts should be of soft iron or steel which will stand bending down upon itself without fracture; if they break or crack under this treatment, it is evidence of a dangerous condition. (See "Specifications for Chemical and Physical Properties of Steel," Page 151.)

In assembling cylinders of this sort, special care should be taken to see that the holes in the cylinder head align properly with those in the cylinder. The use of bolts with a conical shoulder or bearing surface underneath the head is undesirable, and may cause accidents from the bending effect which results when the bolt is tightened, if the alignment is not perfect. This is likely to start cracks at the base of the threads. Cap- or stud-bolts with a flat bearing surface under the head or nut are preferable.

Floor Drainage

Suitable provision should be made for draining floors around wash wheels, centrifugal extractors, etc.

Sanitation is an important matter in laundries, and good conditions as regards ventilation, light, etc., undoubtedly have an appreciable effect in preventing accidents; in fact, all the ordinary hazards are increased by poor sanitary conditions.

The rules of the Wisconsin Industrial Commission in this connection are very good, and may well be followed in all laundries.

They call for heat deflectors for the rolls of all roll body ironers, and the protection of shoe body ironers with non-conductive material. They also specify exhaust systems to remove excessive heat or steam in all rooms where flatwork ironers are operated.

In addition to the above they include the following specific requirements: —

(*a*) Ample washing facilities, with hot and cold water, soap and towels, should be provided and placed within easy reach of the markers and others handling soiled clothes.

(*b*) Markers and others handling soiled clothes should be warned against touching the eyes, mouth, or any part of the body on which the skin has been broken by a scratch or abrasion; and they should be cautioned not to touch or eat food until the hands have been thoroughly washed.

(*c*) Persons with abrasions on the hands or wrists should not be allowed to handle soiled clothing until such abrasions are adequately protected from infection by bandages or gloves.

(*d*) Over-garments should be provided for workers while handling soiled clothes, and such garments should be washed frequently.

(*e*) Markers should be forbidden to shake or carelessly handle soiled clothing so as to raise unnecessary dust. This dust may contain tubercular or other germs, which are easily transmitted in the air.

(*f*) Markers and others handling soiled clothing and who also handle laundered linen, should thoroughly wash their hands and faces and change their working garments before leaving the marking room.

(*g*) Under no circumstances should persons be allowed to sleep in rooms where laundry work is done.

(*h*) Wherever possible, the washing should be done in a separate room.

CHAPTER 36

REFRIGERATING PLANTS

ANY break in the refrigerating piping or equipment, which permits the escape of ammonia, may involve serious hazard to human life. For these installations special ammonia piping and fittings should be used, so as to minimize the danger of such parts giving way. In addition to this the following precautions should be taken: —

1. Some means should be provided for relieving excessive pressure in the compressor, in case a valve in the discharge line should be accidentally closed. This may take the form of a relief valve incorporated in the design of the machine, or a separate relief valve installed between the compressor and first shut-off valve in the discharge line. The escape from the relief valve may be piped into the suction side of the system, to avoid waste of the liquid when the valve operates.

2. Gage glasses should be provided on all tanks where it is desirable to indicate the height of the liquid; these should be suitably safeguarded, to protect the attendant's eyes in case a glass should break. (See Fig. 2.) Gage cocks should be of self-closing type.

3. Provision should be made for shutting down the compressor and closing emergency valves controlling the various portions of the system from a point outside the room, from which they can be operated with safety.

4. Suitable ventilating ducts or outlets should be provided at or near the ceiling of all rooms containing high pressure equipment, to permit escape of gases in case of accident.

5. A suitable emergency helmet should be provided and worn whenever it becomes necessary to enter a gas-filled room or compartment. (See Figs. 1 and 3.)

6. Two or more exits, arranged so as to eliminate danger of employees being trapped in any part of the room, should be provided for all rooms containing high-pressure equipment.

Fig. 1. Air Pump and Protective Suit.*

Fig. 2. Safety Gage.†

Fig. 3. Air Helmet for Emergency Work.†

The gage shown in Fig. 2 has an ordinary tubular glass enclosed in a gas-tight metal fitting, with a heavy glass section in front through which the height of the liquid can be observed.

The helmet shown in Fig. 3 can be quickly slipped on and secured. Fresh air is supplied from a tank on the rear of the hood, by opening a valve. The tank is filled by a hand pump.

* Courtesy of Eastman Kodak Company.

† Patented.

CHAPTER 37

PAPER INDUSTRY, PRINTING, ETC.

BISULPHITE DIGESTERS

In ordering new digesters, the use of butt and double strap joints should be specified. The single strap joint commonly used in the past has contributed to serious digester accidents. It is similar in effect to the lap joint which is generally condemned for boiler service. (See Chapter 11.)

Unless the boiler pressure is limited in such a manner that it will not exceed the safe working pressure of the digester, an effective reducing valve should be provided in the line, with ample safety valve capacity (on the low pressure side) to properly relieve the pressure in case the reducing valve should fail.

Digesters should be carefully examined at least once per week for acid leaks, and the relief valves should be tested at similar intervals.

MECHANICAL GUARDS

The Industrial Commission of Wisconsin has issued the following safety orders for paper mills. These orders were prepared by a committee of paper manufacturers and representatives of the Commission.

Calenders — Doctors. On all machine calenders used in paper mills, except super-calenders, each roll must be equipped with an efficient doctor. (See Fig. 1, P. 320.)

Calenders — Feeding Belt. (On all machine calenders, except super-calenders, where the paper is taken over the top roll to be fed into the first nip, a feeding belt or other efficient device must be provided to conduct the paper into the first nip and thus make it unnecessary for the operator to use his hands in this dangerous place. (See Figs. 1 and 2, P. 320.)

Driers — Doctors. On all paper machines with drier felts, each lower drier must be equipped with an efficient doctor. (See Figs. 1 and 2, P. 320.)

NOTE: It has been found from experience that doctor blades made of well-seasoned straight-grained maple are equally as efficient as blades made of iron or bronze, and are cheaper. Wood blades will not cut the face of the driers.

Drum Winders Guarded. On all drum winders where the drum and paper roll run in on the operating side, the point of contact must be guarded. (See Fig. 4, P. 321.)

Winding Reels — Space Between. The winding reels in paper mills used with the paper machine, where the rolls of paper run in, must be guarded or the reels must be so constructed that it is impossible to have less space than 8 inches between the reels of paper when they reach the maximum size.

NOTE: In order to limit the space between the reels a permanent stop may be placed below the button reel and above the top reel, which will limit the size of the reels.

Barkers and Chippers — Speed Governor. All barkers and chippers must be so equipped that the speed is maintained within safe limits.

NOTE: (*a*) The term "safe limits" used in the above order shall mean the maximum safe speed as prescribed by the manufacturer of the machine. The records of accidents in Wisconsin caused by explosions of discs on chippers and barkers reveal the fact that practically all of them were caused by overspeeding and would have been prevented by an efficient governor to regulate the speed.

(*b*) All barkers and chippers should be thoroughly inspected and tested at least once each week to detect cracks and flaws in the discs.

Various other forms of safeguards for paper mill equipment are shown on Pages 320 and 321. All gearing, belting, shafting, etc., should be protected, in accordance with standards outlined in Chapters 14 and 17. The provision of locking belt shifters for cutters, dusters, beaters, washers, and other machines, to avoid injuries to operators through the belt creeping and starting the machine accidentally, is important.

SANITATION IN PAPER MILLS

The following orders of the Wisconsin Industrial Commission on sanitation in paper mills are recommended for general adoption: —

Rag Sorting Tables — Exhaust System. All rag sorting tables where operators stand and sort rags and other materials which throw off dust, must be equipped with an efficient exhaust system. (See Chapter 9.)

Rag Cutting and Threshing Machines — Located in Separate Room. All rag cutting and rag threshing machines must be located in rooms separate from any rooms in which other work is being done.

Washing Facilities for Women. In all paper mills where women and girls are employed, adequate washing facilities must be provided, including warm water.

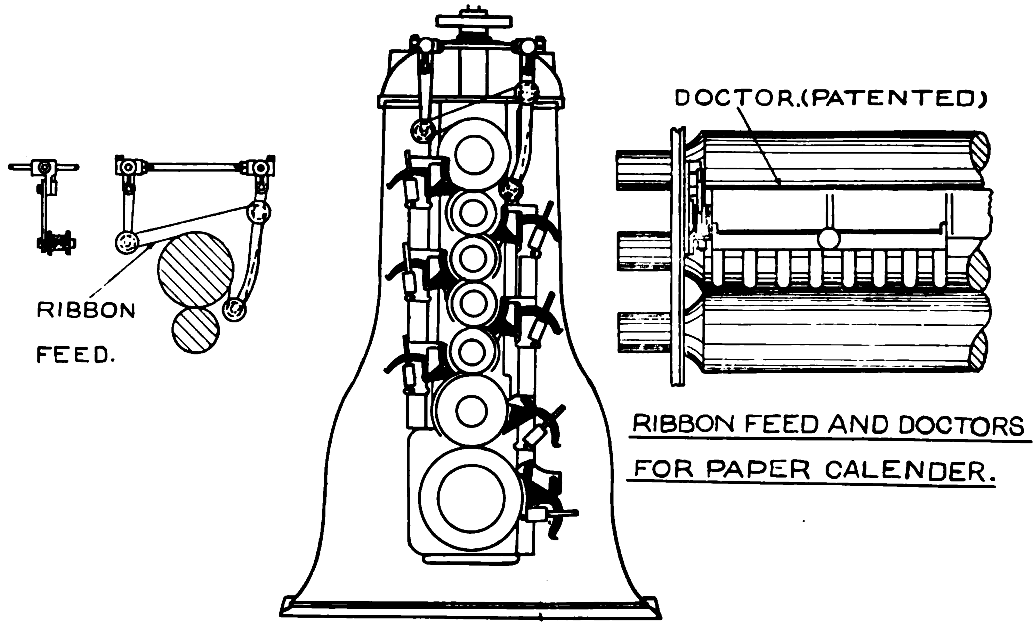


Fig. 1. Ribbon Feed and Doctors.

The ribbon feed (Figs. 1 and 2) starts paper between upper rolls, and the doctors carry it automatically through the others. This practically eliminates danger of fingers being caught in the rolls.

Fig. 2. Calender with Ribbon and Doctor Feed.

Fig. 3. Guard with Hinged Door for Gearing, Sprockets, etc., of Cutter.*

Fig. 4. Guard for Rag Duster.*

*** Courtesy of Neenah Paper Company.**

Fig. 1. Well-Protected Paper Machine.

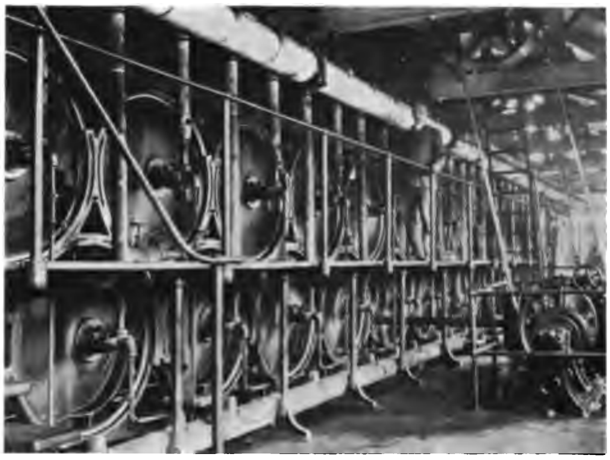


Fig. 2. Note Arrangement of Belt Guards, Gear Guards, Railings, etc.

Fig. 3. Paper Machine Protection.*

Protection of "back line," ventilating hood, etc., for paper machine is shown in Fig. 3.

Fig. 4. Guard for Drum Winder.*

It is stated that at least two winder accidents have been prevented by the guard on this machine.

Fig. 5. Enclosure of Core Wheel, etc.*

Fig. 5 shows a neat guard of woven wire construction.

* Courtesy of Neenah Paper Company.

PRINTING ESTABLISHMENTS

The mechanical hazards of gearing, belting, etc., are found in most of the printing machinery now in use. In many cases where gear guards have been provided they do not completely protect the mesh point of the gears and accidents are likely to happen from persons slipping, reaching, etc., and being caught by the gears. (See List of gear accidents on Page 166.) Such hazards should be eliminated. (See Chapter 17.)

The use of Locking Shifters (or individual motors) is important for printing machinery in order to prevent the accidental starting of the press while operators are working about it.

Fly-wheels and Gear Wheels having spokes through which an arm might be projected should be guarded. Discs of metal or fibre fastened to the wheels meet the need satisfactorily. (See Fig. 4, P. 323.)

Rollers, such as feed rolls of folding machines and matrix rolls of presses, should be guarded. This can usually be done by fixing a rigid bar or shield in front of the roll. (See Fig. 5, P. 323, and Fig. 2, P. 326.)

Shearing or Crushing Actions about presses, linotype or monotype machines, etc., where there is danger of fingers or hands being caught and crushed, should be guarded. (See Figs. 4 and 5, P. 324.)

On Cylinder Presses openings in the frame in front of the operator's position should be guarded wherever feet or other members might be projected through these openings and caught by a reciprocating part and crushed.

The use of some form of safety tread having an effective non-slipping surface is desirable on steps or platforms around large presses, and railings are needed in some conditions.

Platen Printing Presses and Cutting and Creasing Presses are a hazardous type of machine. (See Fig. 3, P. 323.) The hazard can be practically eliminated, however, and the following alternative forms of protection are recommended, preference being in the order given below: —

1. Automatic feed, which does not necessitate operative's hands being brought into a dangerous position. (See Fig. 4, P. 323.)
2. Automatic stops, which prevent the platen from closing if a hand is caught between it and the type. (See Fig. 1, P. 323.)
3. An automatic "throw-out" device which tends to push the operator's arm out of the way as the press closes. (See Fig. 2, P. 323.)

Paper Cutters are another hazardous type of machine. Positive mechanical stops or "non-repeating" devices which will prevent the press from taking a second stroke unexpectedly, should be provided for power driven cutters. (The principle here is similar to that described for power presses. See P. 192.)

Treadle latches should also be installed, to prevent the cutter from being tripped accidentally. (See Fig. 3, P. 316.)

A lock or block should be used which will make it impossible for the machine to operate while knives are being repaired or adjusted. When cutting narrow edgings, a wooden tool should be used rather than the hand, to hold the material in place.

Hand-operated cutters should be provided with effective finger guards. (See Fig. 1, Page 326.)

Linotype and monotype machines should be equipped with shields in front of the moulds, where necessary to prevent the operator being burned by molten metal which may fly from the machine.

At some points shear-actions are formed in which fingers may be crushed by the action of the machine. (See Fig. 5, P. 324.) Such places should be guarded.

These machines should preferably be placed in a room isolated from those in which other work is done. Hoods and exhaust systems should be provided, to carry away the heat and lead vapors.

In electrotype work, saws should be provided with effective guards. (See Fig. 3, P. 324.)

Routing machines should preferably be in a separate room or enclosure. (See Fig. 2, P. 324.) Routing machine operators should wear goggles to protect their eyes from flying particles. Respirators should also be worn to prevent the inhalation of lead dust.

Fig. 1. Platen Press with Automatic Safety Stop. (Pat.)

Fig. 2. Platen Press with Automatic Throw-Out Device. (Pat.)

Fig. 3. Hand crushed in Cutting and Creasing Press.*

The press shown in Fig. 1 is arranged so that the power is thrown off and the brake thrown on, instantly stopping the press, if a hand is caught as it closes.

The automatic feed (Fig. 4) practically eliminates all hazard in operating this type of press, at the same time increasing the output.

Accidents have occurred from operators having their hands caught between the " make-ready " and matrix roll. A good guard for this point, consisting of a fixed bar, is shown in Fig. 5. Note also guards for gear and rack.

Fig. 4. Cutting and Creasing Press with Automatic Feed. (Pat.)

Fig. 5. Guards for Matrix Roll (A), Gear (B) and Rack (C) of Press.†

* Courtesy of Massachusetts Industrial Accident Board.

† Courtesy of The Brocton Publishing Company.

Fig. 1. Finger Guard (indicated by arrow) for Paper Folder.*

Fig. 2. Routing Machine Enclosure.†

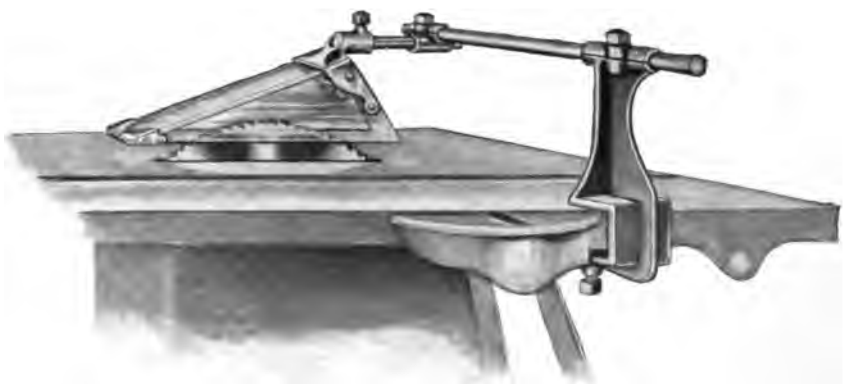


Fig. 3. Guard for Electrotype Saw.

A guard-plate has been provided (Fig. 4) to prevent a hand from resting on the frame of the machine and being crushed by the reciprocating table.

The arrow (Fig. 5) shows where a finger was crushed between the framework of a linotype machine and a carrier which passes it. This danger-point has been protected by a wire screen.

Fig. 4. Guard ("X") for Crushing Action at Rear of Miehle Press.‡

Fig. 5. Guard for Shear-Action in Linotype Machine.

* Courtesy of Birnie Paper Company.

† Ginn & Company.

‡ Oxford Print.

Fig. 1. Finger Protectors (Pat.), caught in Corner Staying Machines.

Fig. 2. Guard for Corner Cutting Machine. (Pat.)

Each of the protectors shown in Fig. 1 was caught in actual service, and saved a finger from injury.

Fig. 2 shows a finger guard in front of a corner cutting machine.

The corner staying machine shown in Fig. 3 is so arranged that positive pressure is only applied when the head is within $\frac{5}{32}''$ of the anvil. The device will not lock and exert pressure with a finger under the head.

A good type of finger guard in front of rotary slitting knives is shown in Fig. 4.

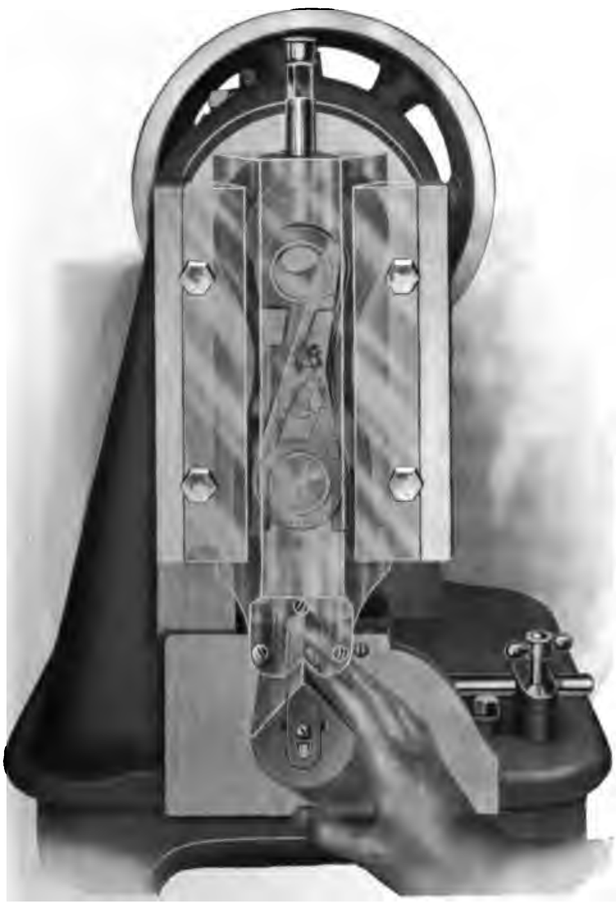


Fig. 3. Protected Corner Staying Machine. (Pat.)

Fig. 4. Slitter Knife Guard. (Pat.)

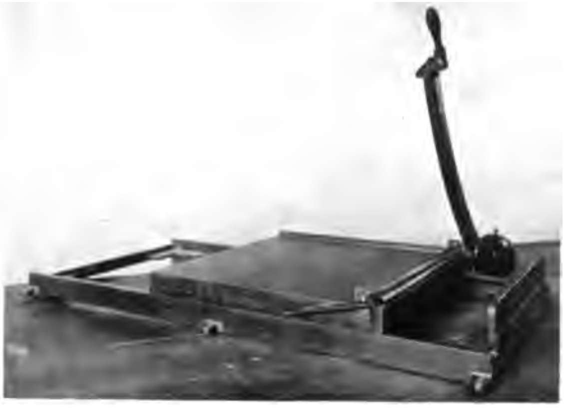


Fig. 1. Finger Guard for Paper Cutter. (General Electric Co.)

Fig. 2. Guarded Pressure Rolls on Folding Box Gluer.*

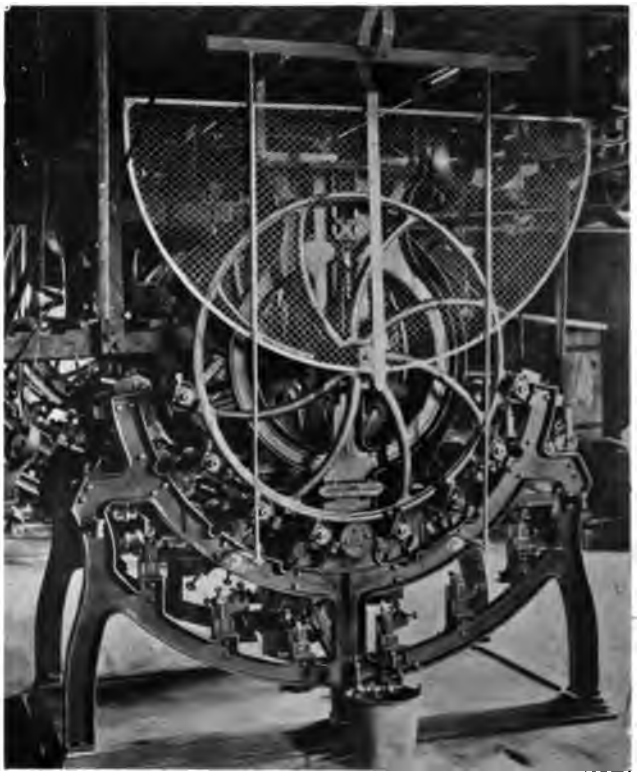


Fig. 3. Guard (raised) for Color Printing Machine.†

Figs. 1 and 2 show effective types of finger guards.

Fig. 4. Guard (lowered) for Color Printing Machine.†

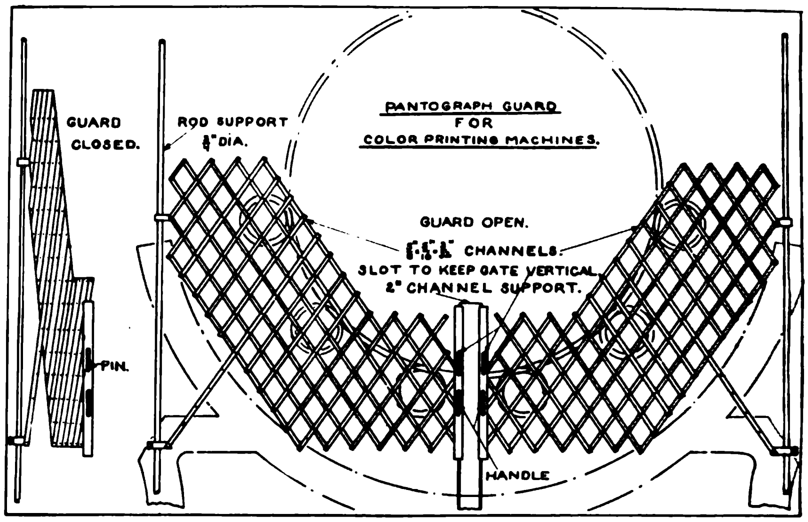


Fig. 5. Pantograph Guard for Color Printing Machine. (Standard Wall Paper Co.)

The guards shown in Figs. 3 and 4 are carried by pipe guides which slide on vertical rods. A flat spring midway between the rods holds the guard in its upper position.

Another convenient guard for wall paper machines is shown in Fig. 5.

* Courtesy of Eastman Kodak Company.

† York Wall Paper Company.

Gasolene, benzine, or other inflammable liquids should be brought into the workrooms in small quantities only and should be kept in safety cans. (See Figs. 2 and 3, P. 357.)

Good housekeeping is an important matter in printing establishments. Waste paper and scrap should be cleared up frequently and should not be allowed to accumulate in quantities which will create a fire hazard. (See Chapter 40.)

Danger of lead poisoning is present, to a certain extent, in the printing industry. Precautions for avoiding injuries from this source are given in Chapter 52.

Cleaning liquids used for removing dried ink may give off poisonous vapors which will cause serious injuries. Such work should only be done in the open air where there is good ventilation, or under an adequately ventilated hood.

PAPER BOX INDUSTRY

Various hazardous machines are used in this industry, of which the corner staying machine has probably contributed the largest number of accidents.

Corner Staying Machines. This machine is similar in hazard to the power press or stamping machine, and in view of the rapidity with which skilled operatives work it is not surprising that many injuries have occurred on these machines as used in the past, which were commonly without protection.

Steel finger protectors (see Fig. 1, P. 325) have been instrumental in preventing many accidents or reducing their seriousness. It is sometimes difficult, however, to get operatives to use them.

A much more effective safety provision for these machines has been recently developed. This consists of an arrangement which prevents the head from exerting enough pressure to cause injury if a finger or hand is caught underneath it. (See Fig. 3, P. 325.)

This is a positive safeguard and its use is strongly recommended. Where, for any reason, machines are not equipped with a device of this kind, finger protectors should be worn.*

Corner cutting machines, scoring machines, slitting machines, gluing rolls, etc., should be provided with fixed guards, so arranged as to prevent fingers from entering the machines and being injured. (See Fig. 2, P. 325, Fig. 2, P. 326, and Fig. 4, P. 325.)

COLOR PRINTING MACHINES

Machines of this type, used for printing wall paper, etc., contain dangerous gearing which has caused a number of serious accidents. Objection is commonly made to guarding this gearing, on account of the fact that it requires frequent adjustment. Practical gear guards for these machines have been developed, however, examples of which are shown on Page 326.

* Occasionally a protector may be crushed in on the finger, but it is doubtful if this inflicts any worse injury than would occur if no guard were used. Such cases are rare at best, and are more than counterbalanced by the number of accidents prevented.

CHAPTER 38

CANDY FACTORIES

ACCIDENTS in the candy industry (aside from those caused by belting, gearing, refrigerating and other equipment covered in separate chapters of this volume) result principally from rolling and cutting machines and mixing kettles. The illustrations on this page show characteristic safeguards for such equipment.

Fig. 1. Guarded Nougat Cutter.

Fig. 2. Guarded Caramel Cutter.

In Fig. 1, a safety pusher, chained to the machine, is illustrated. This pusher has a handle which the operator grasps, thus keeping his fingers out of the way of the knife.

Guards in front and over the top of circular knives of caramel cutter are shown in Fig. 2. The belts and gears of this machine are also guarded.

Fig. 3. Chocolate Kettle Cleaning Stick.

Fig. 4. Guarded Chocolate Enrober Shaft.

The discharge outlet of chocolate kettles occasionally becomes clogged. If a finger is used to clear this outlet, it may be cut off by the revolving scraper inside. Fig. 3 shows a stick, chained to the kettle, to be used for this purpose.

A girl operating the chocolate enrober shown in Fig. 4 had her hair caught on the shaft indicated by arrow, and was almost scalped. A loose-fitting tube or sleeve now encloses the shaft completely. This sleeve ordinarily revolves with the shaft, but stops revolving if touched from the outside.

CHAPTER 39

MINING

THE necessary safety provisions for the special hazards of mining are being thoroughly covered by bulletins and technical papers of the U. S. Bureau of Mines. As this data is quite voluminous and can be obtained upon application to the Bureau (at Washington, D.C.), no general discussion of the subject will be given here.

The protection of mechanical equipment, however, and many other safety provisions described elsewhere in this volume, are also applicable to the mining industry.

Fig. 1. Trip with Safety Chains, in Addition to Center Coupling.*

Fig. 2. Stretcher Car for Bringing Injured Men out of Mine.*

Fig. 3. Water Connection for Washing Down Dust.*

Fig. 4. Apparatus Room at a Rescue Training Station.*

Fig. 5. Guards for Trolley Wires, Signs, etc.*

Fig. 6. Pneumatic Engine used to Avoid Danger of Fire.*

*** Courtesy H. C. Frick Coal and Coke Company, subsidiary of United States Steel Corporation.**

CHAPTER 40

FIRE PREVENTION AND FIRE EXTINGUISHING

THE structural conditions which affect fire hazard have been discussed in Chapter 6. There are other phases of this hazard, however, which may cause serious accidents or loss of life, even though the building proper is of the most approved type. This results from the introduction of inflammable material in the form of goods or stock which are being manufactured, sold or handled, as well as in shelving, furniture and other equipment of various sorts.

The fact that the contents of a building may support a disastrous fire, independently, has been proven too often and too well. The fire in the Iroquois Theatre which occurred on December 30th, 1903, caused the loss of five hundred and sixty-six lives out of an audience of about eighteen hundred people; this notwithstanding the fact that the fire lasted only thirty minutes. Some of the upholstery, hangings, etc., in the auditorium were scarcely scorched; the building was injured only to a slight degree and with comparatively little effort was again ready for use.

The Asch Building fire on March 25th, 1911, resulted in the death of one hundred and forty-five persons, on the eighth, ninth, and tenth floors, although no serious damage was done to the building, and work might have been continued uninterruptedly on the lower stories so far as any immediate effect of the fire was concerned.

All danger from fire can never be entirely eliminated, but it can be largely reduced if proper precautions are taken to, —

(1) Prevent a fire from getting started; or, —

(2) Extinguish it before it can gain headway, or hold it in check until persons in the building can escape.

The question of fire prevention and extinguishing is a large one, for a full discussion of which reference should be made to standard works on the subject such as the "Manual of Fire Protection Inspections and Tests," published by the National Fire Protection Association; "Rules and Requirements of the National Board of Fire Underwriters"; Hand-Book of Fire Protection for Improved Risks, Crosby-Fiske; Fire Prevention and Fire Protection, Freitag. Only a brief summary of special matters which may well be looked out for by safety inspectors and safety committees will be given here.

FIRE PREVENTION

One of the common causes of fires is spontaneous combustion in waste or rags which have been used to clean machinery or in some other manner have become saturated with oil.

The vegetable drying oils (linseed, etc.) are particularly liable to spontaneous combustion under such conditions, on account of the fact that they absorb oxygen in drying and during this process considerable heat is evolved.

Approved metal cans with self-closing lids should be provided for taking care of oily waste. It should never be left lying around on the floors or in rubbish heaps, etc.

Where scrap of an inflammable nature is produced, as in clothing manufacture, the floors should be kept reasonably free from trimmings, etc., at all times, and this material should be removed at least once per day.

Waste chutes should be of metal, brick or other incombustible material and should be equipped with self-closing doors at both top and bottom. Storage bins should also be of incombustible construction and should have self-closing covers.

Steam pipes should never be permitted in scrap or refuse bins, nor should they be allowed to come in contact with wood or any inflammable material.

Furnaces, ovens, radiators, stoves, and similar equipment, which raise the temperature above normal, are a source of fire hazard, and wood or other combustibles should not be permitted to remain in close proximity to such equipment.

Smoking should be prohibited on all premises where either the building or its contents are of such a character that they may take fire. In order to keep this rule constantly before all concerned, it is well to post "No Smoking" signs in conspicuous places.

Matches should not be carried in clothing or allowed to lie around loose. It is well to establish a rule that only safety matches (i.e., those which must be scratched on the box) shall be used.

Metal lockers should be provided in preference to wood; they should be of open-work construction, or so arranged as not to obstruct the flow of water from sprinklers or hose.

Gasolene, benzine, naphtha, and other volatile oils should not be stored within a building; they should be brought in as needed, in small quantities, in standard safety cans. (See Page 357.) The practice of storing oils under stairways is relatively common, but is obviously dangerous, and should not be allowed.

(See also Chapter 46.)

The use of open lights should be avoided so far as possible, and should never be permitted where explosive dust or gases may be encountered. (See "vapor-proof globes," Page 125.) If gas lights are used, they should preferably be fixed rigidly in position; if permitted to swing, any woodwork with which they might come in contact (including ceilings, two feet or less above jets) should be protected by shields of metal or other incombustible material.

Where gas is used for light or fuel, it is important to have a valve outside the building, arranged so that the main supply can be shut off quickly.

FIRE EXTINGUISHING

Nearly every fire is so small at the start that a breath or a cupfull of water would extinguish it. The thing to be feared is that the first tiny flame will be unnoticed until it has grown beyond control.

Mill Fire-Brigades, Good Inside Fire Hose, Chemical Trucks, etc., are desirable, for coping with fires and preventing property loss. They need scarcely be considered, however, from the standpoint of safety to human life, since it should be possible to empty any building of its occupants before much use could be made of these auxiliary means of fighting a fire, which cannot be brought into play immediately.

Of greater importance, from this standpoint, are fire pails and hand extinguishers, which one person can use unassisted, and which are ready for instant service.

Fire Pails

One of the earliest forms of fire extinguisher, namely, a pail of water, still does good service and has a record for extinguishing innumerable fires at the start that might otherwise have developed into conflagrations. Fire pails should be provided in such numbers and locations as to make them quickly available in case of emergency. The National Board of Fire Underwriters requires at least twelve pails to every five thousand feet of floor area, and specifies that not over one half of the required number per floor may be replaced by chemical extinguishers or by casks, in the proportion of one extinguisher, or one 60-gallon cask, to six pails.

Pails should be of galvanized iron painted red* and marked with the word "Fire" in large letters, and they should not be used for any other purpose.

Where exposed to extreme cold, the water may be rendered non-freezing by the addition of about two pounds of chloride of calcium, or salt, to each pail.

Patented bucket-tanks, in which the pails

* While red paint has been commonly used in the past for marking fire pails, white has been suggested as preferable, on account of the fact that white pails can be more quickly distinguished, — particularly at night.

are nested in a tank of non-freezing solution in such manner that when one bucket is removed another is ready to be lifted out, may also be obtained. (See Fig. 3, P. 333.)

Fire pails should be inspected at regular intervals to see that they are properly filled and ready for use.

Chemical Extinguishers

The hand chemical extinguisher of three gallon capacity, is another excellent device for quenching a fire at the start. This consists of a metal tank containing a soda solution, and arranged so that when it is inverted a bottle of sulphuric acid within the tank is emptied into the solution. This generates carbonic acid gas, forcing the liquid out through a flexible hose connection. (See Fig. 1, P. 333.)

These extinguishers should be refilled at least once in six months, a record of the date of filling being kept on a tag attached to the tank. It is well to discharge the extinguisher by inverting it, as in actual service. Care should be taken to see that the hose is free from obstruction. High pressure is developed at the time of discharge, and serious accidents have occurred from the bursting of extinguishers on account of the openings having become clogged.

Various makes of chemical extinguishers are approved by the Underwriters' Laboratories (Chicago, Ill.), as being of good design and construction; lists of these may be obtained upon application. Approved apparatus is marked with the Underwriters' label

Automatic Sprinklers

The most important single agency for extinguishing or controlling serious fires and thus preventing the loss of human life, is undoubtedly the automatic sprinkler. This device has the advantage of applying water automatically through the fusing and opening of sprinkler heads, at any point in a protected building where a fire occurs. (See Page 334.)

Sprinkler heads are generally arranged to open at about 160° F., but may have a higher melting point in furnace rooms or other locations where the ordinary temperature is unusually high.

The following table, taken from the National Fire Protection Association Quarterly, Vol. 6, No. 4, is of interest in this connection. It shows the percentage of efficiency of automatic sprinklers in a large number of fires, covering a long period of years:—

AUTOMATIC SPRINKLER EFFICIENCY

Fires for	*Year ending April, 1913*		*Period from 1897 to 1913*	
	No.	*Per cent*	*No.*	*Per cent*
Extinguished fire	777	58.86	8,527	63.2
Held fire in check	489	37.04	4,310	31.9
Total successful	1,266	95.90	12,837	95.1
Unsatisfactory	54	4.1	663	4.9
Grand total	1,320		13,500	

This indicates that in more than ninety-five per cent of the total of 13,500 fires, the hazard to human life was obviated by the use of the sprinkler equipment.

Most of the unsatisfactory sprinkler fires are due to the human element, rather than the mechanical one. The majority of failures occur on account of the water having been shut off for various reasons,—in some cases from neglect or carelessness, in others, for repairs, on account of freezing, etc.; in a few cases, water was shut off too soon after a fire, which broke out afresh. Only a fraction of one per cent of the total is attributable to defective or obsolete equipment.

The record of the Factory Mutual Fire Insurance Companies in this matter is quite conclusive. During the forty-eight years since sprinkler equipment was generally adopted in their risks, only twelve deaths by fire have occurred, in plants employing at present, 1,500,000 people.

Three of these fatalities resulted from persons going back needlessly into burning buildings, to save personal effects, and four were members of public fire departments, killed in

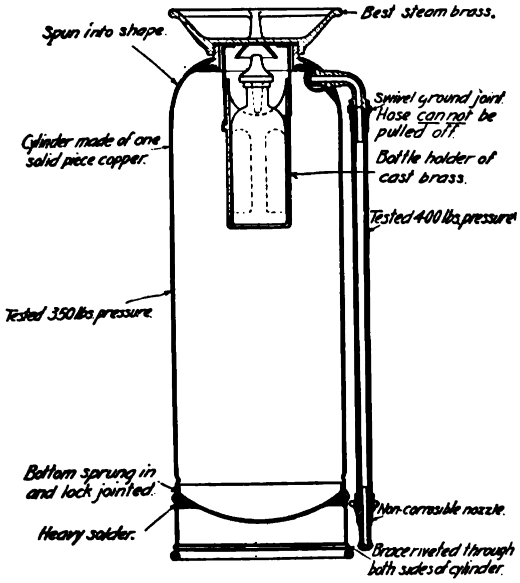


Fig. 1. Three-Gallon Hand Chemical Fire Extinguisher.

Fig. 2. Wire Guard for Gas Lights.

Fig. 3. Fire-Bucket Tank.

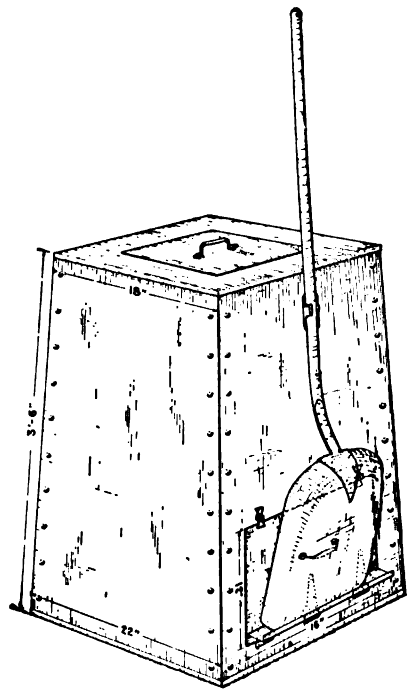


Fig. 4. Metal Sawdust Box and Shovel.*

Fig. 5. Sand Box to Extinguish Fire in Japanning Outfit, etc.†

The extinguisher shown in Fig. 1 is filled with bicarbonate of soda dissolved in water. Sulphuric acid pours from the bottle into this solution when the extinguisher is reversed, thus causing the formation of carbonic acid gas, under pressure, and forcing a stream of solution through the hose.

Guards, as illustrated in Fig. 2, should be provided for swinging gas jets, to prevent contact with inflammable materials.

When a bucket is removed from tank shown in Fig. 3, the one beneath it automatically fills, and the handle rises.

By means of a long-handled scoop shovel, as shown in Fig. 4, quantities of sawdust can be thrown a considerable distance.

The bottom of overhead sand box shown in Fig. 5 can be dropped by means of lever at left-hand side, thus covering dipping-pan with sand. A trip-cord or automatic device with fusible link might be used advantageously. Note also automatically-closing fire door in background, standard exit sign, and fire pail on post.

* Courtesy of Associated Factory Mutual Fire Insurance Companies.

† Courtesy of General Electric Co.

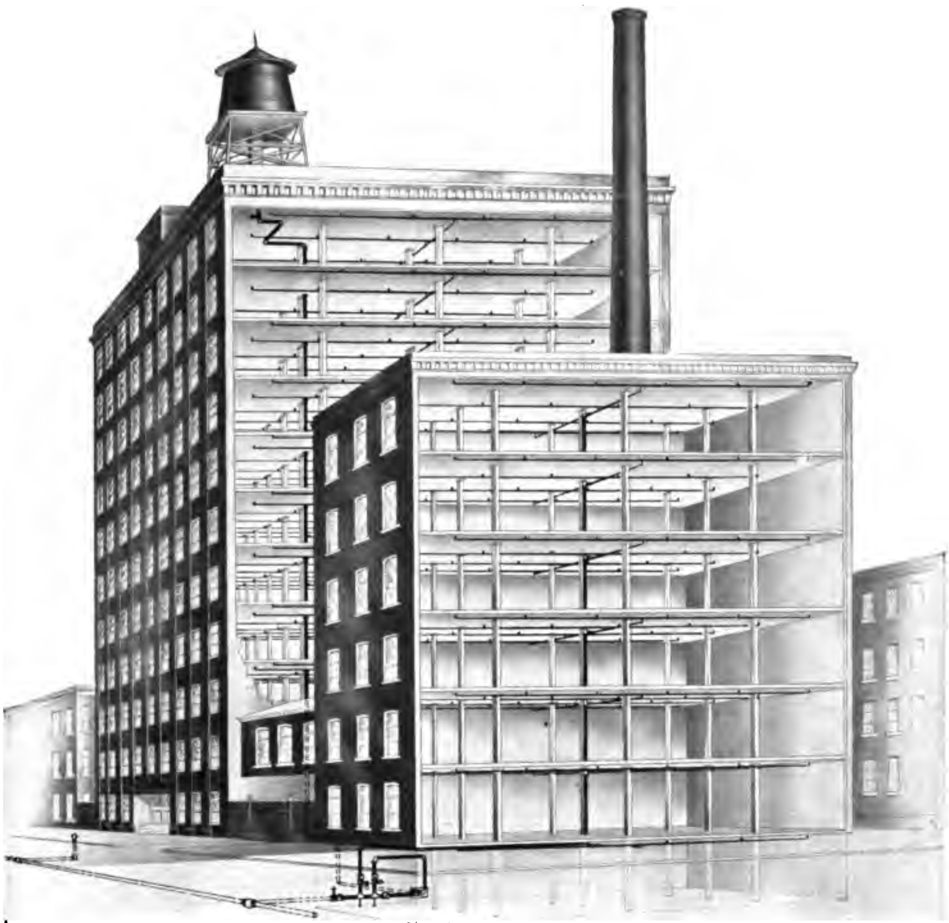


Fig. 1. Sectional view of buildings equipped with automatic sprinklers.

The automatic sprinkler system is designed to protect a building and its contents, by the melting and opening of sprinkler heads at any point where a fire may occur. The heads are usually spaced about 8′ to 10′ centres, so that each head controls from 64 to 100 sq. ft. of floor area.

Figs. 2, 3 and 4 show the detailed construction of a well-known type of automatic sprinkler head. Parts "F," "G," and "H" are held together by fusible solder, which starts to melt when the temperature reaches about 155° F. The water pressure throws these parts and the glass disc free from the head; the water then shoots in a solid stream through the $\frac{1}{2}''$ aperture in diaphragm "C," strikes deflector "J," and is showered in every direction.

Fig. 2.

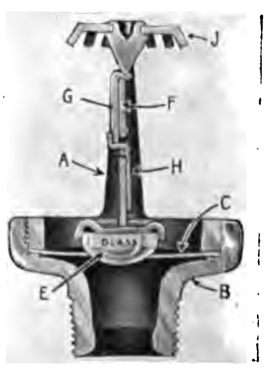


Fig. 3.

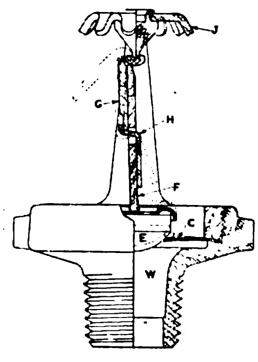


Fig. 4.

Usually two independent water supplies are required for sprinklers, so as to maintain operation of the system if one supply should fail. In Fig. 1 a gravity tank is shown, in addition to the connection to water main in street. Automatic alarms are used, to give notification in case of opening sprinkler heads.

A study of several thousand fires in sprinklered risks has shown that about 30% of these fires were extinguished by the opening of one head only, thus indicating how easily a fire may be put out at the start. The value of sprinklers for safeguarding life as well as property is becoming generally recognized.

the performance of their duties; this leaves only five employees who were unable to save themselves in a period of thirty-nine years, to date, or about *three ten thousandths of one per cent* of the total. (See "Preservation of Life in Factory Fires," L. H. Kuhnhardt, "Safety Engineering," October, 1913.)

Automatic sprinklers have well justified their cost, through the saving of property loss and the continuity of business which results from their installation. Equally important, if not more so, is their effect in reducing the danger of catastrophes to human life, which are liable to result from uncontrolled fires.

Fortunately, the saving in fire insurance premiums is so great as to pay a large return on the investment, and make the installation of automatic sprinklers advantageous from this standpoint alone. There are reputable companies that will install a system of sprinkler protection, and take as their pay the resultant insurance saving for a few years, after which the system will be turned over to the building owner, free of charge.

Under these conditions, there would seem to be no good reason why automatic sprinklers should not be installed in all buildings where there is any hazard to human life from fire, particularly those of combustible construction, or having inflammable contents, and high buildings where the problem of providing satisfactory emergency egress is a difficult one.

Oil Fires

Water is of little value in extinguishing most oil fires, and may merely serve to spread the flames. For this service pails of sand may be used advantageously, and sawdust has been found to give good results.*

Dry powder extinguishers may be effective if applied while the fire is small, but it is difficult to throw the powder any distance or with much accuracy, so their value is limited.

There are small hand pumps or extinguishers containing about one quart of liquid (usually some mixture with carbon tetrachloride as a base) which are of value in certain locations. This liquid is a non-conductor and evaporates without leaving any deposit, so it is advantageous for use in electric power houses, the cabs of electric cranes, lacquer or gasolene tanks, etc. When thrown on a fire, it gives off a gas which does not support combustion and it may be effective in putting out an oil fire in a confined space. In an open location where there is plenty of room for diffusing the gas, the value of this type of extinguisher is limited. (See also "Volatile and Inflammable Liquids," Chapter 45.)

* An interesting report bearing on this subject appeared in the National Fire Protection Association Quarterly for October, 1913 (No. 2, Vol. 7), giving the results of some tests by the Factory Mutual Laboratories. These tests showed that sawdust was very effective in extinguishing fires in lacquer, particularly when sodium bicarbonate was mixed with the sawdust, in the proportion of about 10lbs. of the bicarbonate to 1 bushel of sawdust. (For a good type of sawdust box and shovel, see Fig. 4, Page 333.)

CHAPTER 41

FIRE DRILLS AND FIRE-ALARM SYSTEMS

FIRE DRILLS

In all factories having a considerable number of employees located above the second floor (say 50 or more), exit drills should be established, *unless* the building is of fire-resisting construction with incombustible contents. (See Chapter 6.) Such drills are essential in providing against fire catastrophes for the following reasons: —

First — To make sure that adequate exit capacity has been provided, and is being properly maintained. The only practical way to determine this is by an actual trial, because of the varying conditions which are encountered in different plants, or which may arise in a given plant. A fire drill will bring to light any exit inadequacy, and permit of its being corrected. If such inadequacy is not discovered until a fire occurs, many lives may be needlessly sacrificed.

Second — To inspire confidence in the employees and prevent their becoming panic-stricken at the first alarm of fire.

Third — To familiarize the occupants of a building with all available means of escape, and to provide for a prompt alternative action in case one of the ordinary exits should be cut off.

Fourth — To establish a systematic arrangement which will prevent congestion and overcrowding from persons on different floors trying to use the same stairway. The hazard from this condition is especially great for buildings occupied by several tenants, unless concerted action is taken in advance and a harmonious working plan adopted.

A fire drill, if it is to be of real value, must be carried out with serious purpose. A perfunctory and careless drill may retard, rather than hasten, the emptying of a building in case of fire.

A pamphlet giving general requirements for fire drills in factories (also in schools, department stores and theatres) is issued by the National Fire Protection Association. This pamphlet outlines the duties of the various members of the organization, such as Fire Chief, Assistant Chief, Floor Captains, Floor Lieutenants, Room Captains, etc. It is suggested that those interested in the establishment of fire drills secure copies of this pamphlet, to which reference may be made for details.

A good set of rules and suggestions for fire drills in factories has been prepared also by the New Jersey Department of Labor (Colonel Lewis T. Bryant, Commissioner) from which the following paragraphs are quoted: —

Method and Manner of Egress. It shall be the duty of the Factory Chief to designate the means of egress to be used by the occupants of the several floors, together with the general scheme of organization or procedure in the event of a fire alarm or actual fire. The various methods of egress should be used for drill, at different times, in order to familiarize the operatives with all the means provided for leaving the building. The permanent method of leaving the floors in a fire drill should be as near as possible to the means of egress usually used in leaving the building.

Wherever possible a separate means of egress should be provided for each floor.

Where it is necessary to have the same means of egress used by more than one floor, it is suggested that the floors be designated as far apart as possible, so that the operatives on the lower floors will in all probability have left the building before the operatives on the upper floor reach the entrances to the stairway on the lower floors. The lower floors have the right of way, except in cases where female operatives and children are concerned; the latter shall in all cases have the right of way over men, irrespective of their location in the building.

Where stairways are wide enough for two lines of people, the use of a hand rail in the centre is suggested, so that those from one floor or section of the building can use one side of this stairway, and those from another the other side.

Where fire walls are provided the drill should be arranged with the idea of promptly moving the operatives through the building from the side of the fire wall on which the fire occurred to the other side, and thence from the building by means of the regular means of egress.

An assistant should be especially assigned to the duty of operating the fire door protecting the opening between sections of the building, with instructions to see that it is not closed until all the operatives have vacated the side of the building where the fire is in progress.

One person should be assigned to the entrance of each egress used, to assist in preserving order. The person assigned to supervise the exit by means of a fire escape should see that the door leading to the fire escape platform is closed when the floor is empty.

Elevators are not to be used as a means of egress in case of fire (except for high buildings. See Chapter 6. Author.) The fire doors on elevator shafts should be promptly closed by persons designated for that duty.

All halls and stairways must be kept clear and properly lighted at all times. Artificial lights should be turned on as soon as they are necessary to provide proper lighting.

Assistants to Inspect Toilets and Dressing Rooms. Each Floor Captain should designate one of his responsible assistants to inspect the toilet and dressing rooms at the alarm of fire, as part of the fire drill, to see that they are promptly emptied, so that no one will be left behind. It shall be the duty of those responsible on each floor to be absolutely certain that all factory operatives, especially females and children, have left the building.

Fire-escapes. Designated persons should see that all windows opening upon the fire escapes are promptly closed, and then take their places at the entrances to the assigned means of egress, to assist in preserving a rapid and orderly exit, without any overcrowding or undue excitement.

Fire-escapes must be unobstructed and kept clear and free from snow and ice at all times. Some person should be assigned to this duty.

Skirt guards should be provided for women required to use fire-escapes. (These guards are simply elastic bands which may be worn about the waist and slipped down over the skirt during a fire drill, thus leaving the hands free to grasp the railing.)

Where fire-escapes are used as a method of egress after dark, they should be lighted with electric lights controlled by a switch which specified persons are to operate, or some other satisfactory method. Electric lights to illuminate the fire-escapes and stairways should be wired on a circuit entirely separate from the general wiring of the building, so that in case of a failure in the lighting arrangements of the building during a fire, these methods of egress would still be properly lighted. Additional protection will be provided if the power is secured from a separate source.

All entrances to fire escapes should be plainly marked with signs and lights. (See Chapter 6, Page 40.)

Instructions. The following instructions for fire drills must be posted on each floor of a factory building, and in each room, where the floors are sub-divided: —

Fire Drill Instructions

Fire drills are intended for the safety of operatives, and each employee should assist in successfully conducting the drills, realizing that their safety is greatly increased thereby. The stronger should assist and encourage the less vigorous or more timid.

Organization

The Factory Chief is in immediate command when fire alarm signals sound.

Floor Captains are in direct control of each floor and their instructions should be carefully obeyed.

The Floor Captains will designate when and by what egress you are to leave the building. Wait until you receive his command to march.

Follow your Aisle Leader.

In the Event of Fire

Immediately send in alarm by operating nearest fire-alarm box.

Telephone without delay to fire headquarters and send in alarm from auxiliary box or nearest city fire-alarm box.

When Alarm Apparatus sounds in Workroom

Operatives must
- Stop work.
- Shut off power.
- Stop machines.
- Shut off gas and other open flames.
- Close doors and windows opening upon or under fire-escapes.
- Put chairs, stools and other obstructions on top of or under benches to clear the passageway.
- Form line promptly with front of column facing the usual egress aisle and wait word of command from Floor Captain.

At Command to March

March in a rapid orderly manner from building, two abreast as instructed, not crowding upon the couple immediately in front of you, following your Aisle Leaders.

Preserve the interval in line between yourself and couple in front of you.

Retain formation until dismissed or the line is returned to building.

Women and children always have the right of way.

Fig. 1. Binghampton Clothing Company Building, Ten Minutes after Fatal Fire started.*

Fig. 2. Fire Escape on Plant in Newark, N.J., after Fire.*

Fire drills, in order to be of value, must be carried out with the utmost promptness. A misunderstanding of signals, and delay to obtain wraps, were responsible for some of the lives lost in the fire shown in Fig. 1.

Fig. 2 shows a fire escape down which several hundred employees marched in safety when a fire occurred in the building. Doors and windows underneath this escape were protected with wired glass, which clearly demonstrated its value. Note also effectiveness of wire screens above glass skylight at lower right-hand corner.

Fig. 3. Clothes Room in Building shown in Fig. 2 after Fire.*

Fig. 4. "Out" Sign illuminated by Fire Alarm. (General Electric Co.)

Fig. 3 illustrates the value of a properly organized exit drill. The operatives, according to drill regulations, left the building without waiting to secure their wraps, a cause of delay in the Binghampton catastrophe.

Fig. 4 shows a sign to indicate which exit should be used in the fire drill. The General Electric Company has organized drills in buildings containing many employees, even though they are of high-grade fire-resisting or mill construction, protected by automatic sprinklers.

* Courtesy of "Safety Engineering."

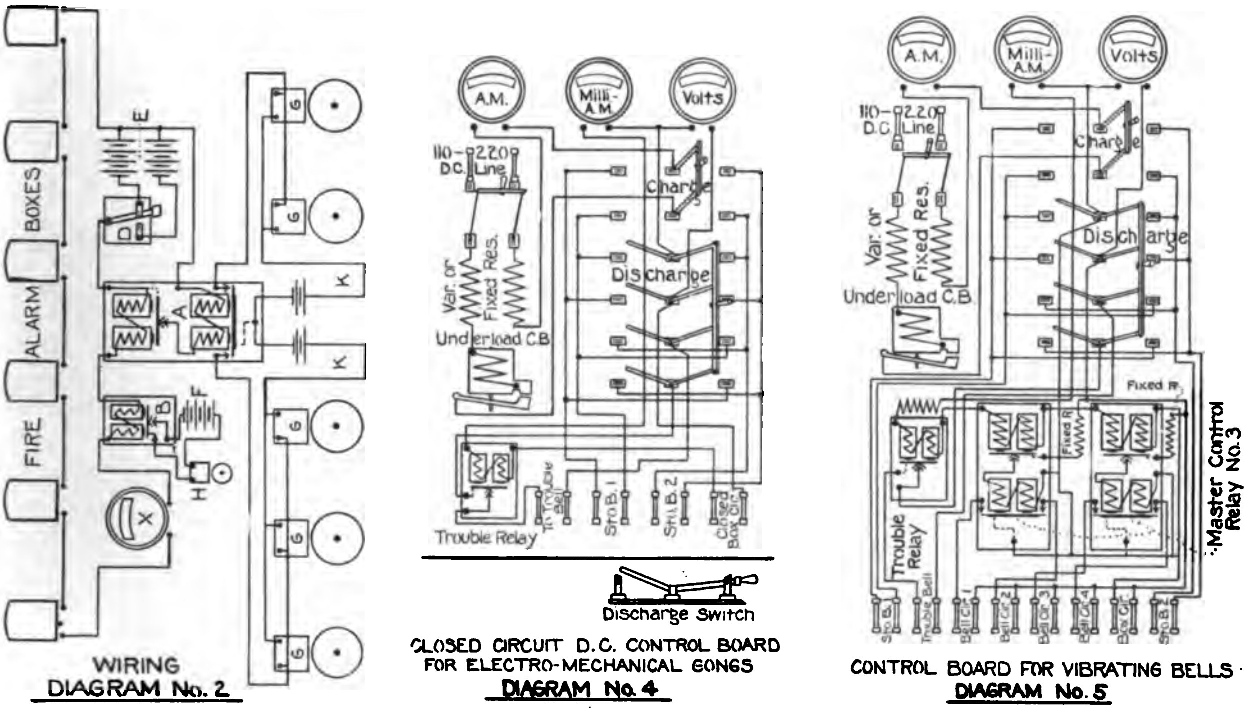


Fig. 1. Fire-Alarm System, — Wiring and Switchboard Diagrams.*

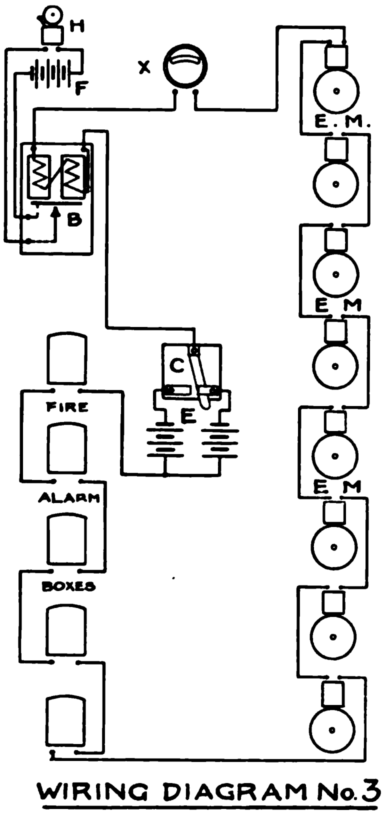


Fig. 2. Wiring Diagram.*

EXPLANATION OF SYMBOLS

A — Multiple contact master relay No. 3 of approved type and design. Closed or box circuit magnets to be wound to 25 ohms res. Bell circuit magnets to be wound to 50 ohms res. Relay to be mounted vertically, magnets up, and enclosed in a metal case under lock and key. All magnet windings to be of enameled wire.

B — Approved type fire-alarm relay No. 1 wound to 25 ohms res., mounted in a metal case under lock and key, in a vertical position, magnets up.

C & D — Single pole double throw approved fire-alarm type switch.

E — Duplicate closed circuit batteries consisting of enough 300-amp. hour approved closed circuit cells to cause a current flow of 50 milli-amperes based on an E. M. F. of .65 volt per cell. Storage batteries may be substituted.

F — Local battery of approved cells.

G — Approved vibrating bells (of not less than 8″ in diameter, except by special permission).

H — Approved covered trouble bell (not less than 3″ dia.); magnets not less than 10 ohms res.

K — Open circuit batteries of approved wet or semi-dry cells. A sufficient number of cells shall be provided in each set to secure a maximum efficiency in operation.

E. M. — Approved single stroke electro-mechanical gongs wound to not less than 20 ohms resistance. (Diameter to be not less than 8″, except by special permission).

X — Milli-ammeter; scale to read 0-200 milli-amperes.

Note. All wiring to be installed in rigid iron conduit or steel armor.

* From drawings prepared by the New Jersey Department of Labor.

Don't

Don't run.
Don't lag behind, breaking up columns.
Don't scream or make unnecessary noise.
Don't laugh or talk.
Don't cause confusion.
Don't remain in toilet or dressing room
Don't return for your clothing.
Don't try to use elevators.
Don't attempt to leave building except in accordance with fire drill regulations.
Don't fail to assist in carrying out instructions.

FIRE-ALARM SYSTEMS

In order to make sure that warning will be given promptly after a fire is discovered, a reliable fire-alarm system is required. This should provide for transmitting signals to all rooms which must be emptied of their occupants and may also include arrangements for notifying local authorities or city fire departments. The fire-alarm service is so important that thorough dependability is an absolute necessity for this equipment.

A closed-circuit arrangement throughout is preferable, as it will then give warning automatically as soon as there is any failure of, or interference with, the current supply. A combined open and closed-circuit system may be used, however, if arranged with divided circuits and other approved precautions.

The use of Automatic Fire-Alarm Boxes which give the proper signal by merely pulling a lever or breaking a glass, is also of great importance. In a recent fire involving the loss of 35 lives, a fire drill had been inaugurated with signal bells rung by ordinary push-buttons. When a fire actually occurred, the person who discovered it was unfamiliar with the signals used for the fire drill; he held his finger on a button continuously for two or three minutes; the employees did not understand that this was a signal to leave the building, and invaluable time was lost as a result. (See Report of Mr. H. W. Forster, "Binghampton Clothing Company Fire," published by National Fire Protection Association, 87 Milk St., Boston.)

SPECIFICATIONS FOR FIRE-ALARM SYSTEMS

An excellent set of detailed specifications for fire-alarm systems was issued June 1st, 1913, by the Department of Labor of the State of New Jersey, Colonel Lewis T. Bryant, Commissioner. This was revised January 1st, 1915. (See P. 339.)

The New Jersey specifications were adopted as a basis for a proposed set of regulations to be issued by the National Fire Protection Association, with certain modifications, chiefly by way of rendering them of more general application. These regulations have not been finally approved at the time this matter goes to press but copies can be obtained upon application to the Association (87 Milk St., Boston). They undoubtedly represent the best standards for fire-alarm systems yet formulated; and it is recommended that they be used in ordering new equipment (except where definite detailed specifications have been adopted by the State, as is the case in New Jersey and New York).

CHAPTER 42

EXPLOSIVES

GENERAL

In addition to the commonly recognized explosives such as dynamite and gun powder, destructive explosions may be caused, under certain conditions, by various kinds of inflammable liquids and gases, as well as by mineral, vegetable and animal dusts, etc. (See Page 346.)

In many cases it is difficult to draw a line between substances which are explosive and those which are merely inflammable; in fact the latter class merges into the former, and where conditions are right for the rapid burning of any substance a genuine explosion may take place, even though the substance in question would not ordinarily be considered explosive.

Much valuable work in determining the possibilities of explosive and inflammable materials and formulating rules for their safe handling and transportation has been done by the Bureau of Explosives, 30 Vesey Street, New York City, — Colonel B. W. Dunn, Chief Inspector. (See Pamphlet No. 7 of the Bureau, which describes the general characteristics of various types of explosives, and includes a comprehensive list, with definitions, of "dangerous articles other than explosives," such as inflammable liquids and solids, oxidizing materials, corrosive liquids and compressed gases.)

Transportation of Explosives

National rules governing the transportation of explosives may be obtained upon application to the Interstate Commerce Commission at Washington, D.C. In addition, some States and municipalities have local rules which must be conformed to, and which should be looked up for any given locality. (See "Regulations of the District Police for the Keeping, Storage, Manufacture, etc., of Explosives, in the Commonwealth of Massachusetts," "Laws and Regulations Relating to Mines, Quarries, and Tunnels," issued by the New York State Department of Labor, "Regulations of the Municipal Explosives Committee of the City of New York," etc., etc.)

Location of Explosives

Where explosives are used in industrial processes, the arrangement of storage places, and of buildings in which the processes are carried on, should be such as to reduce to the minimum the danger in case an explosion should occur. Where there are several buildings in which explosives are stored or used, such buildings should be so isolated or protected from one another that an explosion in one building would not be likely to affect the others. Barriers, such as hills or artificial mounds, offer considerable protection from the force of an explosion. The danger radius varies, however, largely in proportion to the amount of explosives on hand at a given time. Tables giving permissible quantities of explosives for a given degree of isolation are usually contained in regulations such as these mentioned above.

Handling and Use of Explosives

An excellent discussion of this subject, containing illustrations of storehouses, thaw houses, use of fuses, detonators, etc., is contained in bulletin No. 80 of the United States Bureau of Mines, entitled "Primer on Explosives for Metal Miners and Quarrymen."

The following information prepared by the Illinois Steel Company for the guidance of its employees gives, in brief form, rules representing good safety practice in the use of high explosives. These rules conform, in general, to the recommendations of the Bureau of Mines.

NO ONE SHALL BE ALLOWED TO HANDLE OR ASSIST IN HANDLING HIGH EXPLOSIVES IN ANY WAY UNTIL HE HAS RECEIVED INSTRUCTIONS SATISFACTORY TO THE SUPERINTENDENT OF HIS DEPARTMENT AND THE SAFETY INSPECTOR.

Shipping

1. Explosives, when offered for shipment by rail, must be in proper condition for transportation, and must be packed, marked, loaded, stayed and handled while in transit in accordance with the regulations of the Interstate Commerce Commission.
2. EMPTY BOXES PREVIOUSLY USED FOR HIGH EXPLOSIVES ARE DANGEROUS AND MUST NOT BE USED AGAIN. EMPTY METAL KEGS WHICH HAVE BEEN USED FOR THE SHIPMENT OF BLACK POWDER, NOT CONTAINED IN AN INTERIOR PACKAGE, MUST NOT BE USED AGAIN.
3. A car containing any dynamite must be protected by attaching to the outside of the car on both sides and ends — the lower edge four and one-half feet above the car floor — a standard "EXPLOSIVE" placard.
4. Upon receiving shipments of explosives examine the packages carefully, to discover ruptures or other serious damage during transit.
5. Explosives shipped by wagon shall be handled so as to comply with the city and state laws.
6. It is unlawful to carry dynamite or caps on any public conveyance used in transporting passengers.

Storage

1. Dynamite shall be stored in a special house, so constructed as to comply with the requirements of the law.* (See Fig. 4, P. 343.) Such houses or magazines shall be provided with a ventilator at the roof, with matched flooring, and shall be lighted from the outside only. The presence of any form of light or fire within such magazine is prohibited by law.
2. It is forbidden to PREPARE or KEEP primers, percussion caps, detonators, candles, matches, cotton waste, tools or any article liable to cause an explosion or fire, or any iron, steel or grit, in any magazine.
3. The magazine shall be kept locked.
4. No repairs shall be made to the magazine until all dynamite has been removed and the building thoroughly scrubbed.
5. Great care must be taken in handling and opening boxes of dynamite. USE A WOODEN MALLET AND A WOODEN WEDGE. Avoid friction and blows as much as possible, and NEVER open the box in the storage house or magazine.
6. Dynamite should be protected as far as practicable during storage against heat, moisture, fire, lightning, projectiles and theft. To keep any nitroglycerin explosives permanently thawed they should be stored where the temperature does not go below 52 degrees F. On the other hand, care should be taken that none of these explosives is subjected to high temperatures, for this will render them more sensitive to explosion and is likely to cause the decomposition of some of them. The temperature of the magazine should not rise above 90 degrees F.

   When dynamite becomes moist the nitroglycerin contained in it tends to run out — that is, what is called exudation takes place — and all the dangers follow that belong to liquid nitroglycerin.
7. Cases of dynamite should always be placed so that the cartridges lie on their side. This decreases the possibility of the nitroglycerin running.
8. Dynamite should be kept stored in the original package until wanted for use. The cartridges should be handled so as not to break the paper wrapper, thereby exposing it to the moisture in the air.
9. Dynamite should not be exposed to the direct sunlight, as this may lead to decomposition.
10. Dynamite should be obtained in as fresh a condition as possible, and should be used as soon as possible, because the longer it is kept in storage the greater the chance that changes will take place in it. Use the oldest dynamite on hand first.
11. All magazines and thaw houses shall be painted a bright red, with the words "MAGAZINE — DANGER" painted thereon in white letters at least six inches high, on a black background.

Thawing

(See Bulletin No. 80 of the U.S. Bureau of Mines for details regarding construction and arrangement of thawing kettles and houses.)

1. As a general thing, dynamite freezes at from 42 degrees to 50 degrees F. and will freeze hard sometimes when the temperature does not affect water.
2. WHILE THAWING, NITROGLYCERIN EXPLOSIVES ARE EXTREMELY SENSITIVE AND SHOULD BE HANDLED WITH GREAT CARE. Dynamite begins to undergo a change at 158 degrees F., and from that temperature up becomes more and more sensitive to shock. At a temperature of a little over 200 degrees F. it will explode from a slight shock, and at a temperature of about 356 degrees F., it will explode simply from heat. For this reason you must not expose the explosive to the direct heat of a fire, or lay it on steam pipes or near a boiler or smoke stack. You may do this for a long time without accident, but it is extremely dangerous. Dynamite allowed to get hot will explode from the slightest jar or from a blow of the tamping rod. To illustrate: Cartridges heated in sand have been known to explode from simply rolling them about in the sand — the sand got too hot; cartridges standing on end near a fire have been known to explode simply from falling over.
3. All thawing of dynamite shall be done in one of two ways: —

   First — In all places where more than 100 pounds of dynamite or other high explosive is used daily, a thaw house shall be erected for this purpose, in accordance with the requirements of the law. The thaw house must never be used as a magazine or storage house. The temperature of this thaw house must not at any time rise higher than 90 degrees F. The heating apparatus shall be so arranged that the temperature cannot rise higher than 90 degrees F., even if neglected.

   Second — Where smaller amounts of dynamite are used, the thawing shall be done in a water tube thawer, but the water must be heated before being put in the thawer. The use of a stove, lamp or direct heat in connection with this thawer is prohibited by law. The water put in the thawer should not be so hot as to be uncomfortable to the hand.
4. No blasting caps or primers or detonators shall be kept in any thaw house or magazine.

* The U.S. Bureau of Mines recommends that storage houses be made of one part cement to six parts coarse sand, as this material is almost entirely disintegrated by explosion so that large pieces will not fly and damage other property. (See Bulletin No. 80.) Storage houses should be protected from lightning; this may be done by installing lightning rods on adjacent poles which are higher than the storehouse.

Fig. 1. Effect of Magazine Explosion on Railroad Train.*

Fig. 2. Scene of Coal Crusher Accident.

This magazine contained 2500 lbs. of explosives, — dynamite, black powder and blasting caps, — and was located 123 feet from track, without intervening barriers. One person was killed and forty injured, with a property loss of $50,000; cause of explosion unknown. This accident illustrates the necessity for maintaining safe distances between storage magazines and railroad tracks, or other locations where persons might be injured if the magazine should explode.

Four men were fatally burned by the ignition of coal dust in the crusher house illustrated in Fig. 2. They carried an open torch into the conveyor-boot to clear out a stoppage of the conveyor.

Fig. 3. Result of Dust Explosion in Feed Mill and Grain Elevator.

Fig. 4. Dynamite Storehouse.

The plant shown in Fig. 3 was completely wrecked, thirty-three employees being killed and as many more injured, by a dust explosion and subsequent fire.

The building shown in Fig. 4 is isolated, well guarded, and properly constructed, but an inspector found a piece of fuse attached to a detonator (in hands of man in photo), lying in a metal bucket containing loose stick of dynamite, inside the storehouse. Such careless practices might result in a serious accident at any time.

* Courtesy Bureau of Explosives.

Fig. 1.

Fig. 2.

Portable Shelter Houses.*

The shelter houses illustrated in Figs. 1 and 2 are used to protect workmen from flying fragments of rocks when blasting is being done. They are arranged so they can be picked up by a locomotive crane, or by a number of workmen, and moved about from place to place as needed.

Attention is directed to the stepped or terraced bank in background of Fig. 1. This is a much safer arrangement for open mines or quarries than a single high bank, as it largely reduces danger from falling rock or other material.

Fig. 3. Device for Blowing Powder into Holes for Blasting.*

Fig. 4. Shield for Charging Vertical Holes, and Duplex Ignition System.*

The shields shown in Figs. 3 and 4 protect powder from sparks which might cause accidental ignition while the holes are being filled; a hand-operated fan is used in Fig. 3, for charging the holes.

Note that a fuse is used in addition to electrical connection in Fig. 4. If the latter should fail to fire the charge the former can be ignited, thus avoiding the hazard incident to removing or working about a charge which has failed to explode.

* Courtesy of Oliver Iron Mining Company, subsidiary of United States Steel Corporation.

5. It is a mistaken idea that dynamite is waterproof, and, therefore, that any amount of soaking or steaming will not injure it. Dynamite soaked in hot water for fifteen minutes and then allowed to steam for half an hour has been found to have taken up over ten per cent of water, an amount that would possibly make it non-explosive. Certainly it would reduce the explosive force by half.

Blasting

1. The handling and firing of dynamite necessarily is very dangerous, both for the dynamiter and for people in that vicinity, and you cannot be too careful.
2. Frozen dynamite, though not so sensitive to blows, is peculiarly sensitive to friction such as that produced by cutting or boring holes in it. The use of frozen or partly frozen cartridges, breaking or cutting them, or drilling them for caps is prohibited by law.
3. Frozen cartridges, if not capped, shall be returned to the thawing apparatus to be thawed.
4. The removal of a primer from a frozen cartridge is prohibited by law.
5. In tamping drill holes, the law requires that wooden rammers only shall be used. Tamping by strokes is forbidden by law, and only direct application of pressure permitted.
6. The use of nitroglycerin dynamite containing over 60 per cent of nitroglycerin is prohibited by law.
7. The use of blasting caps containing less than 9½ grains of explosive mixture, at least 80 per cent fulminate of mercury and 20 per cent chlorate of potash, or its equivalent detonating strength, is prohibited by law.
8. It is unlawful to use leaky dynamite (leaking nitroglycerin).
9. Detonators are very sensitive to heat, friction or blows. Do not drop them or strike them against any hard body. Do not lay them where they may be stepped upon.
10. *In Firing Blasts* it is forbidden to use any other device than an electrical blasting machine. A machine which has been idle for some time will not always generate the full amount of current at the first stroke of the handle, and it is therefore a good plan to "pump it up" just before firing a shot, which will bring the machine up to full strength. (See Fig. 4, P. 344.)
11. If you have occasion to crimp detonators, take the greatest care not to squeeze the composition, and NEVER CRIMP THEM WITH YOUR TEETH, for there is enough composition in one of these small capsules to blow your head off.
12. Keep caps and detonators stored in a dry place, in a building separate from the magazine or thaw house. When carrying or shipping them they should be packed firmly with a quantity of elastic material, such as felt.
13. BEFORE A BLAST IS SET OFF every one within the danger zone shall be notified and all approaches to the place of blasting guarded.
14. When blasting is being done near a building or trestle the men at work there shall be notified.
15. In yards where blasting is continually done, warning whistles shall be installed and signs posted explaining the whistle signals. These whistles, and signs, however, will not relieve the dynamiters from personally warning men in buildings or on trestles or at any point within the danger zone.

In some instances it will be advisable to build substantial shelters for the workmen. (See Figs. 1 and 2, P. 344.)

N.B. — The most dangerous man handling dynamite is the one who has handled it for years, boasts that he is not afraid of it, and even goes a little out of his way to handle it roughly, just to show that he has no fear of it. Familiarity should not be permitted to breed contempt.

Suggested Warning Sign:—

DANGER!! DYNAMITING!!

Whistle tooted for one minute before the blast.

LOOK OUT!!

CHAPTER 43

EXPLOSIVE DUSTS

(*See also Chapter 42.*)

TYPES OF HAZARDOUS DUSTS.

SUBSEQUENT to a serious dust explosion, the British Factory Inspection Department instructed its inspectors to report on the various dusty trades encountered by them, classifying those in which there was danger of explosion, and marking the ones where such explosions had occurred. The following list (taken from the annual report of the Chief Inspector for 1911) shows the tabulated results of these reports, those marked with a * being the ones in which actual explosions had come to the attention of the inspectors.

(1) Works containing farinaceous, saccharine, and starchy dusts	(2) Works containing carbonaceous dusts, e.g., charcoal, coal, coke, graphite, etc.	(3) Works containing dusts of vegetable origin, e.g., cork, wood, etc.	(4) Works containing dusts of animal origin, e.g., bones, hoofs, horn, etc.
*Breweries	*Briquette works	*Cork grinding (linoleum)	Bone grinding works
Cattle food works	*Cement works	*Saw mills (sand papering)	*Refuse hoof and horn grinding works
Confectionery works	Charcoal grinding	Saw-dust grinding and wood flour mills	
Cocoa works	Coal washing	Snuff mills	
*Distilleries	Coke ovens	Tea factories (sifting)	
*Flour mills	Electric carbon works		
Food mills (corn flour)	Foundry blacking works		
*Grist mills	Gas works		
*Maltings	Lamp-black works		
Mustard mills	Mineral and ivory black works		
*Oak husk grinding	*Phonograph record works		
Rice mills	*Rag carbonizing works		
Saccharine works			
*Seed crushing			
Spice mills			
*Starch and gum works			

Explosions in Flour Mills, Grist Mills, etc.

One of the worst dust explosions on record occurred at the works of Messrs. J. Bibby and Sons, Liverpool, England, on November 24, 1911. As a result of this explosion 39 persons were killed and 101 others were injured. All but two of the fatalities occurred to those employed in the plant, the exceptions representing casual passers-by.

The buildings were substantially constructed with brick walls and concrete floors, fitted with automatic sprinklers and lighted by electricity. The processes included the handling, storage, and grinding of cotton seed, nuts, locust beans, etc., used in the manufacture of oil cake.

The cause of the explosion appears to have been the ignition of a cloud of dust caused by a breaking belt, either by an electric flash, or by some one striking a match in the semi-darkness which resulted from the dust being stirred up in this way. This flash ran from room to room and completely wrecked several of the buildings.

The recommendations of the factory inspector for avoiding a repetition of this accident were as follows: —

Rooms used for the purpose should not have other rooms above them, nor should they be adjacent to higher buildings which would be affected in the event of an explosion.

The roof should be such as to offer little resistance in the event of explosion.

There should be no open beams, girders or other ledges, or projections on which dust could lodge.

The floors, walls, machinery, appliances, and any ledges, as above, should be cleansed from dust daily — preferably by a suction cleaner.

Underground rooms are unsuitable for disintegrators or other grinding machinery.

All grinding and mixing machines, hoppers, elevators, worms and conveyors (other than belt conveyors — see below) should be so constructed as to prevent the escape of dust, and preferably provided with exhaust draught. Belt conveyors should be provided with exhaust draught and adequate appliances for interception and removal of dust, at the points where they are filled and discharged.

Efficient electro-magnetic separators should be provided on the feed of each disintegrating or other grinding machine to arrest particles of iron or steel.

No naked gas lights or electric arc lamps should be used in such rooms; and incandescent electric lamps should have outer dust-tight glass covers.

In such rooms Regulation 27 of the Electricity Code requires special protection of conductors, switches, fuses and other electrical apparatus (to make them dust-tight).

No matches or smoking should be allowed.

In connection with grinding and cleaning machinery, the use of a sieve room is unnecessary and dangerous; more modern methods of intercepting the dust such as cyclone collectors or bag-filters should be substituted.

A somewhat similar explosion occurred in the plant of the Husted Milling Company, Buffalo, N.Y., June 24, 1913 (see Fig. 3, P. 243), wrecking the plant and killing 33 employees. After investigating this explosion, Mr. William Newell, mechanical engineer for the State inspection department, included several additional suggestions for the prevention of accidents of this kind, in a report to the Industrial Board (see New York Labor Bulletin for September, 1913), from which the following paragraphs are quoted: —

Rooms completely enclosed are safest. Flues, hoistways, elevator shafts and openings, which afford opportunity for escape of dust to boiler fires, are dangerous.

Where the nature of material permits, the air should be humidified; damp air causes the dust to settle down more rapidly.

Where the dust is produced inside any apparatus (cleaning or grinding machinery, etc.) the latter should be kept tightly shut, or else completely enclosed to prevent any escape of dust.

Machinery in which dust is produced should not be opened until sufficient time has elapsed for the dust to subside after the machinery has ceased running.

Bins should be comparatively small in size, and there should be a greater number of them, if necessary, instead of having a few very large bins, so that if an explosion takes place in one of the bins, its violence will be greatly lessened.

Dust collectors of the cyclone type should have their exhaust led into the open air instead of discharging into the building, as many do. Tubular (cloth) dust collectors, as a rule, exhaust directly into the building, that is, the air is filtered through the mesh of the felt or cloth, the dust being retained inside of the tube, these tubes being cleansed by a light blow from a hammer mechanism which causes the dust to fall down into the exhaust pipe. The presumption is that only the filtered air escapes, and no dust. It would be preferable to isolate these dust collectors in a chamber with an outside vent, because when they become worn or motheaten, there is ample opportunity for leakage of dust. More or less dust escapes from these collectors, even under the best conditions, though perhaps not enough to constitute a real source of danger through explosion.

In feed mills, the discharge spouts to bags are often very steep, and if of any length or height, the material comes down with a rush, causing a pressure of air that is forced out of any openings in the feed bags or spout, and with it clouds of dust, particularly when taking off or changing sacks. A remedy for this is to have the spout deliver at one end of a worm or conveyor which discharges at its opposite end where the sack is hung, or a box may be used in connection where one, two, three or more sacks may be hung, and a valve so arranged that the bags will fill one after the other automatically. Such spouts should be placed at no greater angle than 45 degrees, which would avoid in a measure the great blowing and dusting tendency.

The enclosing of stairways and hoistways is a preventive of the spread of fire as well as tending to confine to one floor a slight explosion which might otherwise become greater. All other openings, such as unused spout holes, should be closed. Belt holes in floors or partitions should be restricted to the smallest possible size and some flexible material used to close even the smallest opening, leaving only bare clearance room for the belt. All bearings and eccentrics should be self-oiling. The best results can be obtained at a slight additional cost by the adoption of ball bearings.

No dust should be permitted to be blown under boilers directly from dust collectors.

Mr. J. W. Anderson, president of the Kornfalfa Feed Milling Company, of Kansas City, Mo., states that when he was connected with the Corn Products Refining Company, some explosions occurred in their starch factories. One way they had of overcoming the danger of these explosions was to keep a live steam jet escaping into the atmosphere, thereby keeping the atmosphere charged with a certain degree of moisture. Their experience had taught them that explosions would not occur when the atmosphere was heavy with moisture. The conjunction of a very dry atmosphere with an accumulation of fine starch flour, under certain conditions, was very likely to cause an explosion.

As a further evidence of the seriousness of this hazard, the following notes on other explosions of grain dust may be included: —

An explosion of grain-dust in the Buffalo Cereal Co., Buffalo, N.Y., in January, 1910, seriously injured nine men, and is supposed to have killed three others who are missing. The explosion occurred in the yellow corn mill, which was wrecked, together with a concrete and brick elevator adjoining it. The wreckage of both buildings caught fire, and the flames spread to other parts of the plant.

An explosion of corn dust occurred at the works of the Corn Products Refining Company, Granite City, Ill., on August 7, 1910. Explosion was on the sixth floor of a building where several workmen were engaged in sacking the corn-dust as it came from a refining plant, about 100 feet away. Two men were killed, and seven others fatally injured.

A grain-dust explosion occurred November 15, 1908, in the oat rooms of the main factory of the American Milling Company's stock food factory at Linden, Ind. The building at once caught fire, and the entire factory was burned. Four men were badly hurt. The force of the explosion wrecked the fire-fighting apparatus of the mill, and as the town has no adequate fire protection little could be done to stop the flames.

Explosions of Coal Dust

Many bad explosions of coal dust are on record. These have occurred not only in mines, where the conditions are relatively favorable, but in exposed locations as well, where the dust was not confined.

Five men were burned, four of them fatally, in an open coal crushing plant near Pittsburg, on April 5, 1913. (See Fig. 2, P. 343.) The crusher was stopped at the time, and the five men went down into the elevator boot to clear the chute which had become clogged. Although incandescent electric lights were available, one of the men carried a lighted torch. A strong wind which was blowing at the time probably stirred up the dust and it was ignited, either from the torch or by a match struck to re-light the torch. The building was of light construction and open at the sides, so there was not a genuine explosion, — merely a flaming of the dust for a few seconds. The men who were killed probably inhaled the flames.

A coal-dust explosion at the plant of the Portland Cement Company, near Florence, Col., January 3, 1911, caused the death of two workmen, and the injury of seven others. The accidents occurred in the second story of the Coal Pulverizing Department, which was being *swept out.*

Explosions of other kinds of dust may also be mentioned, as follows: —

An explosion occurred in the Say Sugar Refinery, Paris, France, in May, 1908, in which two persons were killed and forty-two burned, or otherwise injured; property loss, $100,000; reported to have been caused by a spark from a dynamo, which fired and exploded an accumulation of sugar dust.

An explosion in a sulphur grinding mill completely destroyed the factory of the National Sulphur Works in Williamsburg, N.Y., on February 29, 1908, and so injured three of the workmen that they were not expected to live.

An explosion of sawdust August 6, 1910, wrecked the power house of the Diamond Match Company, at Barber, Cal. Three of the walls were demolished, and the roof blown off. The débris was further damaged by fire. Two employees were fatally hurt, and several others suffered severe injuries.

These represent scattered cases of dust explosions of which many have occurred both in this country and abroad. No effort has been made to accumulate a complete record of such explosions, but it is believed that these examples, most of which were taken from current periodicals, are sufficient to show the possibilities of danger and to justify special precautions, such as those cited above, for the prevention of similar accidents.

Of these precautions, probably the most important and universal are: —

(1) Cleanliness, — to prevent the accumulation of dust in dangerous quantities.
(2) Avoidance of open flames of any kind, and protection from electric flashes by the use of conduit wiring, enclosed equipment, "vapor-proof" globes, etc.
(3) Isolation of dusty processes and separation of buildings to prevent the spread of an explosion.

CHAPTER 44

CELLULOID, AND CELLULOID GOODS MANUFACTURE

PROPERTIES OF CELLULOID (*For a definition of celluloid, see Chapter 47.*)

A THOROUGH study of the properties, use, hazards, etc., of this material, has been made by the Departmental Committee on Celluloid of Great Britain. (See report Cd. 7158—1913.)

This report gives tabulated lists of celluloid fires occurring from a wide variety of causes, among which the following may be mentioned:

Accidental contact with gas light
Spark from emery wheel
Celluloid cases near stove
Overheating of flue
Spark from glazer
Contact with hot water pipes
Spontaneous ignition of dust
Melting sealing wax on parcel
Friction at shafting
Defective light wiring
Bursting of incandescent lamp

A number of cases were also recorded, where *the sun's rays in shop windows* caused ignition.

In testing many kinds of articles, the fuming-off point (that is, the temperature at which disintegration occurs; this generates explosive gases which may or may not ignite spontaneously) was found to vary from about 190° C. (374° F.) to slightly less than 100° C. (212° F.).

Celluloid contains sufficient oxygen in its composition to support combustion, so that the exclusion of air, as by the use of ordinary carbonic acid gas extinguishers, is not sufficient to put out a fire, once started. Water is the best medium for this purpose, and it accomplishes the result by lowering the temperature below the point where decomposition occurs.

Celluloid is not explosive under ordinary conditions, although genuine explosions may be caused by celluloid dust, or by the gases given off by celluloid which has been heated to the "fuming-off" point. The decomposition of celluloid without flame is accompanied by the evolution of large volumes of suffocating gases, which may make it exceedingly difficult to fight the fire effectively.

CELLULOID GOODS MANUFACTURE

In view of the fact that there is always a possibility of serious fire or explosions in the process of celluloid goods manufacture, general safety precautions should be taken along the following lines: —

(*a*) Buildings should be preferably one story, or at most two stories in height. In more than one instance employees in celluloid factories have become panic-stricken at a flash of fire, and jumped from the upper story windows.

(*b*) Buildings used for the manufacture of celluloid articles should be equipped throughout with automatic sprinklers. Water pails should be placed about the rooms so they can be quickly reached in case of emergency. In order to prevent a fire from spreading it is desirable to locate sprinkler heads over burrs, cutters, saws, pointing machines, etc., about one foot above the knives.

(*c*) The different processes should be separated. The arrangement should be such as to limit a fire which may occur, to the space required by that process, and not expose employees of other departments to danger from fire or panic. Cutting, pointing, etc., should be done in separate rooms from those containing steam tables or hot plates used in shaping, bending, etc. Packing and shipping rooms should also be isolated. Fire walls provided with self-closing fire doors should preferably be used to separate the different processes. Doors in such walls should be kept shut.

(*d*) "Housekeeping" conditions are of the greatest importance in this industry. Floors around burrs, saws, pointing-machines, etc., should be thoroughly swept at intervals of about one hour while work is being done. Sweepings should be deposited in covered metal cans, the latter being removed at the end of the day as mentioned later. Walls and overhead beams or joists should also be kept free from dust.

(*e*) If an exhaust system is used to remove dust from the machines, ample draught to keep the pipes clear must be maintained. Pipes should have no sharp bends or pockets in which dust is likely to collect.* (See Chapter 9.)

The Departmental Committee, to which reference has already been made, in addition to a general recommendation that the working of celluloid should not be permitted beneath living rooms, and that it should not be allowed in tenanted risks unless there are adequate means of escape from all parts of the building, submitted the following recommendations:

FACTORIES

A. **In the Workrooms.** (1) The greatest danger is due to the creation of waste. Waste should not be allowed to accumulate on the floor, but should be collected from time to time (if possible as it is created) in suitable receptacles. At the end of the day it should be removed from the workrooms and placed in metal or wooden boxes provided with lids and marked "Celluloid Waste." It should not be stored in sacks. Owing to the fact that a commercial value now attaches to waste, greater care is taken for its safe preservation than was formerly the case.

(2) Saws should run in water.

(3) The amount of celluloid in the workrooms should be limited as far as possible, and should in no case exceed one day's requirements, and finished goods should be removed with all due diligence.

(4) Adequate means of extinguishing fire should be provided. Where the quantity of celluloid is small, buckets of water will suffice; if large quantities are used, there should be hydrants or sprinklers in addition.

(5) Smoking and the introduction of matches into the workrooms should be prohibited.

(6) Open lights and fires are a source of danger; but where only a small quantity of celluloid is worked it does not appear necessary to prohibit them if adequate means of extinguishing fire are provided.† Care should, however, be taken to prevent celluloid coming into contact with open lights or fires, nor should it be left in proximity to these for prolonged periods. It is inadvisable to allow celluloid to remain in contact with sources of heat. The use of sealing wax and soldering should be avoided as far as possible; if such operations are necessary, they should be performed with the special precautions mentioned later.

(7) There should be adequate means of escape, not only from the room, but from each working place; gangways, passages, and staircases should be of sufficient breadth and be kept free from obstruction; doors should open outwards.

(8) The workpeople should be instructed as to the steps to be taken in case of fire.

B. **In the Storerooms.** Many of the smaller factories are supplied with the material they require from day to day. Where there is a reserve stock, it should be stored in suitable receptacles. Stocks, when considerable, should be stored in a special chamber of fire-resisting construction marked "Celluloid Store," in which no means of lighting, except electric light, and no fire should be allowed. The store should be kept locked outside working hours, and celluloid should be taken out of it only to the extent of the immediate requirements of the workrooms. The prohibition as to smoking and the introduction of matches should, of course, apply to the storeroom as well as to the workrooms. Adequate means of extinguishing fire should be readily available. The storage is best effected in a single-story building away from the other buildings of the factory, in which case celluloid other than waste or scrap may be stored naked; failing that, on the top floor of the building. The storeroom should be so situated that a fire arising therein would not endanger the staircase or the exits from the rest of the building. Finished articles should be kept in packages or in suitable receptacles.

WHOLESALE SHOPS AND WAREHOUSES CARRYING LARGE STOCKS OF CELLULOID ARTICLES

(1) All celluloid shall be kept in sound closed boxes or other approved receptacles, except

* The use of exhaust systems in celluloid factories is of doubtful value. In some cases where a fire has occurred, the result has been that it flashed through the exhaust piping to various points, which it might not have reached otherwise.

† (Author's note.)—On account of the nature of this hazard, it would seem wiser to prohibit the use of open lights entirely in rooms where celluloid is handled.

such celluloid as it may be necessary to expose for the purpose of the trade or business, the amount so exposed to be kept as small as possible.

(2) All due precautions shall be taken to prevent the ignition of any celluloid articles, and celluloid articles or receptacles containing the same shall not be kept or taken near to any source of heat which would be liable to decompose or ignite celluloid. Any means adopted for artificially heating or lighting a room where celluloid is kept shall be of such a character or placed in such positions or be so protected as not to be liable to ignite or decompose any celluloid in the room.

(3) Celluloid shall not be kept near any exit in such quantity or such manner that its ignition would endanger the means of escape.

(4) An ample supply of water for extinguishing fire shall be kept available in every room where celluloid is kept.

(5) Where 100 lbs. or more of celluloid are kept in any one room the room shall be of substantial construction, and shall be in such a position as not to interfere with the general means of escape from the building in the event of the ignition of the celluloid. Explosives or highly inflammable liquids shall not be kept in any such room.

(6) Where the total quantity kept exceeds 10 cwts., up to and including 10 cwts. may be kept in accordance with the conditions above described, but the excess quantity shall be kept in a fire-resisting store substantially separated from any other portion of the wholesale shop or warehouse, and in such a position as not to interfere with any means of escape, and with some provision to minimize the danger to neighboring property from shooting flames. Where the entrance to such store is not external to the building, the entrance shall be through a lobby of fire-resisting construction provided with an inner and an outer smoke-proof door closing automatically. Where it is not possible to provide a store as above described, the local authority may consent to the use of a satisfactory store on the top floor in such a position as not to interfere with the means of escape.

Any store as above described shall not be heated, and any artificial lighting inside the store shall be by means of electric bulb lights with double globes, wiring in screwed metal tubes properly earthed, and switches and fuses outside.

SHOPS AND RETAIL STORES

Without outlining definite regulations the Committee gives the following suggestions:

"The amount of celluloid goods displayed without protection should be limited as far as possible, and the reserve stock stored in closed packages or receptacles. The safest position for the bulk of the stock is on the top floor, and it should be placed in positions where, in the event of fire, the exits would not be endangered. Light celluloid articles should not be displayed in baskets on the floor where a match or other burning or smouldering material might be dropped on them. Celluloid should not be exposed to even moderate heat, e.g., in proximity to radiators, flues, or electric lamps. The use of sealing wax on parcels containing celluloid articles should be avoided. Packages containing celluloid should not be soldered without the interposition of a protective plate between the part soldered and the celluloid. Fire buckets or other means of extinguishing fire should be readily available."

It is further suggested that the marking of all packages containing articles largely composed of celluloid would be of value in warning those handling them that special precautions are necessary.

(See also Rules and Requirements of the National Board of Fire Underwriters governing the storage and handling of Nitro-Cellulose Films; and regulations of the Interstate Commerce Commission for the transportation of explosives, etc.)

CHAPTER 45

VOLATILE AND INFLAMMABLE LIQUIDS

(*See also Chapters 40 and 42.*)

INDUSTRIES USING LARGE QUANTITIES OF INFLAMMABLE LIQUIDS

VOLATILE and inflammable liquids such as gasolene, benzine, naphtha, carbon bisulphide, ether, collodion, etc., are necessary in certain industrial processes. They may be used directly, as in dry cleaning, cement mixing, gasolene engines or engine testing, degreasing of skins, etc., or combined as solvents in cements, varnishes, polishes, etc. In all such applications there is danger of serious fires or explosions, unless special precautions are taken to guard against them.

The National Board of Fire Underwriters and the National Fire Protection Association have issued various booklets and pamphlets taking up specific matters, such as oil storage, fuel oil systems, safety cans, etc. A good outline of general requirements in this connection is found in a pamphlet entitled "Suggested Ordinance Relating to the Use, Handling, Storage and Sale of Inflammable Liquids and the Products Thereof," issued jointly by the above-mentioned bodies. The following discussion, outlining the principal safety provisions for work of this kind, is based largely upon standards given in the "Suggested Ordinance."

Isolation of Hazardous Processes

Hazardous processes such as those mentioned above should be located in fire-resisting buildings. Such buildings should be preferably separated by a clear space of at least 10′ from other buildings. Walls, floors and ceilings should be not less than 8″ thick, of brick or concrete, or 4″ of reinforced concrete. All windows, doors, or other openings within 50′ of an exposed building or combustible materials, should be provided with wired glass in standard metal frames, or with fireproof shutters, doors or covers.

Where buildings in which hazardous processes of this kind are carried on adjoin other occupied rooms or buildings, they should be cut off from such rooms or buildings by fire walls. These walls should be preferably solid; if doorways are necessary they should be provided with standard automatic fire doors, which are kept shut except when persons are passing through.

Processes of the kind in question should preferably be located in one story buildings. Floors should be solid with no openings or space underneath in which explosive vapors might gather. Doors should have sills raised at least 6″ above the highest point of floor. The presence of combustible materials, either in the form of building construction or contents, should be minimized in every practicable way. Where there are wood columns or other wooden building members, they should be covered with sheet metal.

Ventilation

Vent openings of at least 20 square inches, should be provided at intervals of approximately 10′ along the walls, at the floor level. These openings should be connected by incombustible flues to the outside air, at a point not closer than 3′ to any window or door opening. Unless such flues slant downward in the direction of the outside, they should be connected with conductors ventilated by sparkless fans run continuously during working hours.

Vapors from gasolene, naphtha, etc., at ordinary temperatures are heavier than air, and will flow from vent openings at the floor line. Where heat is used in the process, however, or where the temperature of workrooms is high, ventilating openings are desirable in the roof also. A good arrangement is to provide such openings with tubes extending to a point near the floor, so the heavy vapors will be removed directly. Steam coils inside the tubes may induce sufficient draught, or fans may be necessary.

Vent openings, skylights, etc., should be covered with 12 x 12 mesh or equivalent brass wire screen, to prevent entrance of sparks or fire.

Lighting

In providing lights the following systems may be used, preference being in the order given: —

(1) Natural light only, supplied through windows.
(2) Electric lights, installed as specified below.
(3) Gas or oil lights in wall openings with sealed glass covers on the inside, access being from the outside of the building only.

Electrical Equipment

All electric lamps and sockets should be enclosed in vapor-tight globes (see Fig. 5, P. 125) and supported on pipe hangers, wired with approved rubber-covered wire soldered directly to the circuit.

Switches, cut-outs, etc., should be located outside the room, or enclosed in approved dust-proof casings with means for external operation, or in dust-proof cabinets with self-closing doors, ventilated to the outside air or located at points where there will be no danger of an electric spark igniting explosive vapors.

Motors should be placed in separate rooms or compartments, properly safeguarded against the entrance of explosive vapors.

Heating

Heating should be by means of steam or hot water. No steam boiler, furnace, or other exposed fire should be allowed within rooms where volatile liquids are used, or in line with vapor travel from such rooms. Heating pipes should be guarded to prevent contact of cloth or other combustible materials with them.

Sewer Connections

Where drains or sewer connections from such rooms or buildings are required, they should not be directly connected to the sewer. Intercepting grease, oil, and inflammable liquid traps or separators, which will completely separate such substances from water and sewage should be provided. Such traps should be suitably ventilated, and grease, oil, etc., removed from the separator and disposed of at regular intervals.

Storage

Storage tanks for volatile oils should be of steel, well built and thoroughly tested. They should be located outside main buildings, and well away from lumber piles or other combustible material. The minimum distance from tanks to buildings or material piles should be not less than 30′, preferably 50′.

The arrangement of storage tanks and piping should be such that any derangement in the system will not permit liquid to flow into the buildings to which it is piped. Storage tanks should be located well below the floors of such buildings, so the liquid will return by gravity into the tank if the pipe should break or valves should be left open. Tanks should be buried at least 2′ below the surface of the ground and should preferably not exceed one carload, or about 10,000 gallons' capacity. (See Fig. 4, P. 355.)

Piping

Piping and fittings should be preferably extra heavy, the system being tested to 150 lbs. hydraulic pressure. Right and left hand couplings should be used in preference to unions. Valve stems should be packed with asbestos or other insoluble material and all-metal cocks should be used where practicable. Where it is necessary to cross a building with an exposed pipe, it should be enclosed within a pipe of larger diameter having open ends outside the building. This is to prevent gasolene from a leak escaping within the building. All leaks should be repaired promptly, the piping being replaced, if necessary, to stop the leak.

Supply System

One of the two following methods is recommended for delivering gasolene or similar liquids to the point within a building where it is to be used: —

(1) The liquid blanketed in storage tank and jacketed piping by inert gas, under pressure, the arrangement being such that a break in the piping will release the pressure of gas and permit the liquid to flow back into the storage tank by gravity. (See P. 356.)

(2) Hand pumps used to pump liquid from storage tank to draw-off valve, the piping being arranged so the liquid will drain back to the storage tank when operation of pump ceases. (See P. 355.)

An excellent arrangement, advocated by the Factory Mutual Fire Insurance Companies is to have a hand pump as mentioned in (2) enclosed in a non-combustible hood projecting from the side of the building and cut off from the room by an automatic fire shutter. (See Figs. 1–3, P. 355.)

Where very large quantities of oil must be handled, or where the storage tanks are located a considerable distance from the point of delivery, pumps operated by power may be used. Where this is done, a systematic method should be worked out which will avoid any possibility of flooding the building with an excessive supply of liquid.

Gravity systems, or the use of air or hydraulic pressure for forcing oil from storage or service tanks are especially hazardous and should not be used. A valve or faucet left open accidentally, or leaking, may permit oil to escape in the building and cause a serious accident.

Draw-off faucets should be of self-closing type. A valve should be provided on the delivery pipe, where it rises from the ground to the hood so oil can be shut off without going back to the pump.

Rubber Cement and Varnish, etc.

In some processes, such as the manufacture of rubber shoes, large quantities of varnish with a naphtha solvent are exposed in dip tanks. Such tanks should be controlled by a valve located at a convenient point outside the room from which it can be operated with safety in case of fire, the liquid draining to underground storage tanks when the controlling valve is opened.

Drying Ovens

Drying ovens used for evaporating varnish, japan, etc., should be preferably steam heated. If gas or gasolene vapor is used for heating it is very important to have the burners completely and securely cut off from the interior of the oven, so there will be no danger of an explosion through the ignition of vapor from the articles which are drying. The space around such burners should be thoroughly ventilated so that an explosive mixture could not collect, and that any leakage from burner would escape outside the building.

Static Electric Charges

A number of accidents are on record, some of which have resulted fatally, due to the ignition of vapors from gasolene by a spark caused by static electricity generated by the friction of the liquid flowing through pipes, funnels or other containers. Undoubtedly this has been responsible for many gasolene fires in the past, for which no reason could be found at the time.

In this connection the following paragraphs, taken from a pamphlet giving laws and regulations of the Massachusetts District Police for Garages, are of interest: —

In the drawing of gasoline from a pump into a metal can, no can should be used that has a wooden bail or handle in such a manner that the wood will intervene between the metal of the can and that of the pump on which it is hung.

In filling the tank of a motor vehicle with gasoline from a metal can, care should be taken that good metallic connection exists, not only between the tank and other metallic parts of the vehicle, but between the funnel and the tank as well. The pouring can should have a piece of copper chain soldered to the nozzle, the other end to rest in metallic connection with the tank or the funnel during filling.

Motor vehicles that are filled by means of a hose direct from a storage tank or a portable tank should have hose with a continuous metallic lining

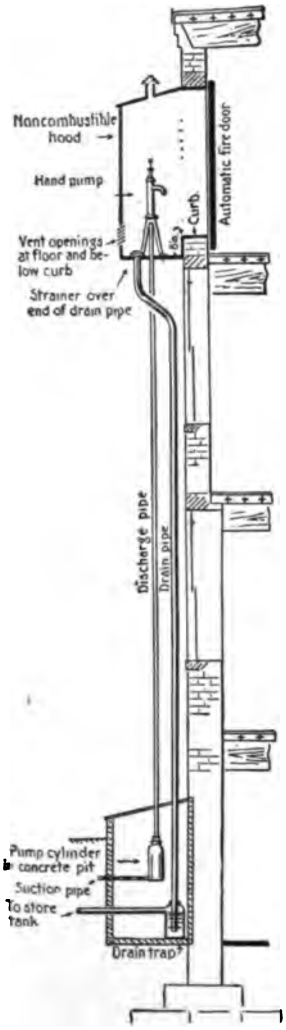


Fig. 1. Hood, Pump and Piping.*

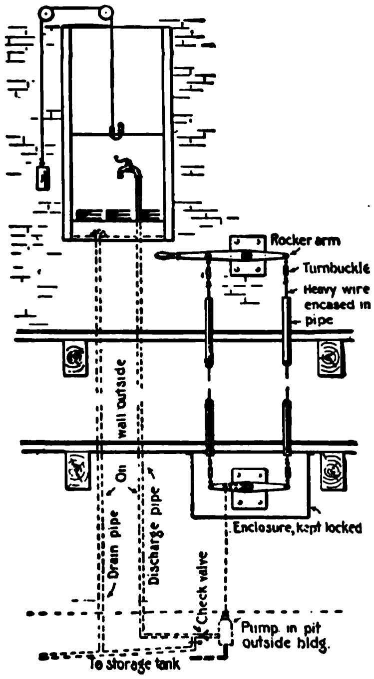


Fig. 2. Hand Pump operated from Distant Point.*

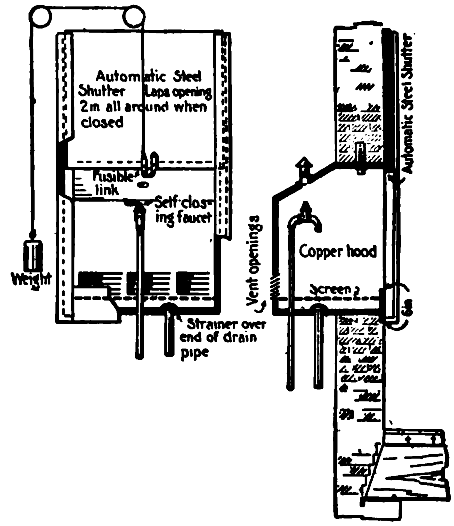


Fig. 3. Detail of Hood.*

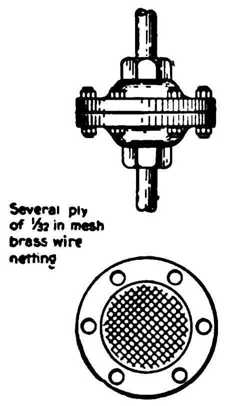


Fig. 5. Detail of Fire Arrester.*

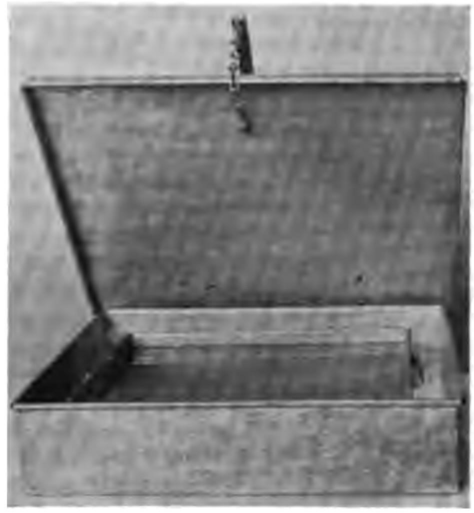


Fig. 6. Safety Dip-Tank for Gasolene, etc.†

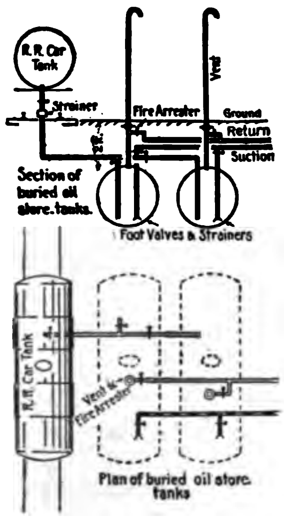


Fig. 4. Storage Tanks and Unloading Station.*

Figs. 1 to 4 show a model system for the safe handling of gasolene and other inflammable liquids.

The dip-tank shown in Fig. 6 has a cover controlled by a fusible link, which will close automatically and extinguish a fire in the tank.

Fig. 7. Automatic Steam Connection for Drying Tumblers.

Should an explosion occur in the tumbler shown in Fig. 7, the circular doors would be thrown open, raising the small handles above the doors and turning live steam into the tumbler.

* Courtesy of Associated Factory Mutual Fire Insurance Companies. † Eastman Kodak Company.

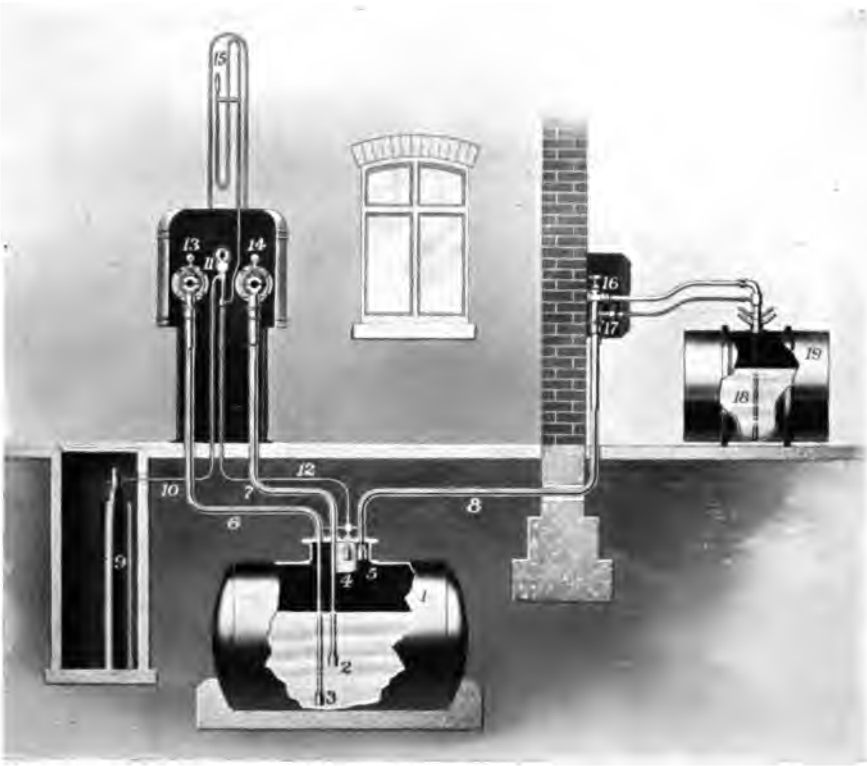


Fig. 1. Gasolene Storage System. (Patented.)

Fig. 2. Jacketed Pipe.

Fig. 1 shows a storage system for gasolene and other inflammable oils, in which safety is made the first consideration.

Pressure is produced on the surface of the liquid in underground storage tank (1, see Fig. 1) by inert gas contained in cylinder 9. This forces the liquid up through pipes 6 and 7 to draw-off valves. A pressure regulator (11) prevents excess gas pressure. All pipes and valves are jacketed (Figs. 2 and 3), the space between the inner and outer walls being also filled with inert gas. In case of any break in the system, the pressure is relieved and the gasolene runs back by gravity into underground storage tank. As it is then "blanketed" by inert gas, there is no danger of an explosion. The storage tank is filled from shipping drum (19) by means of syphon (18). Commercial carbon dioxide or carbonic acid gas, such as is used for charging soda fountains, may be utilized to supply the pressure, or inert gas may be generated locally if the plant is large enough to justify it.

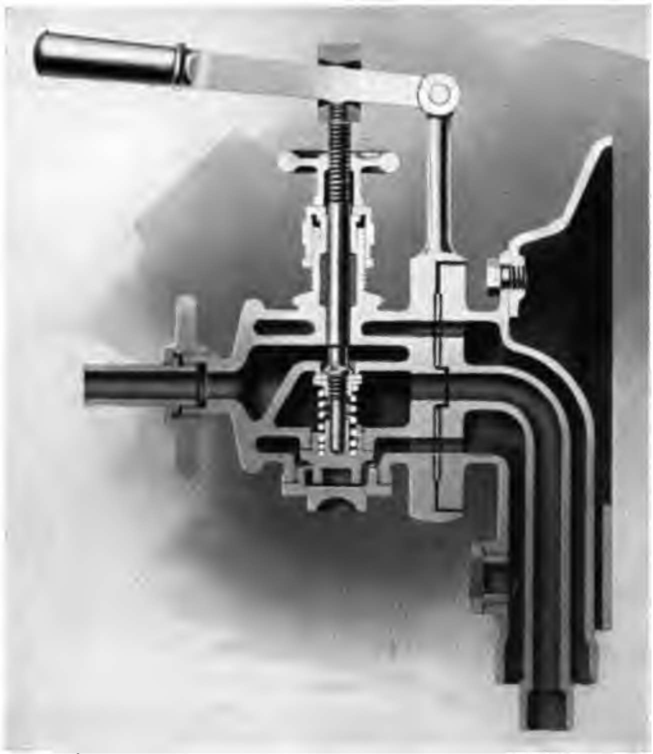
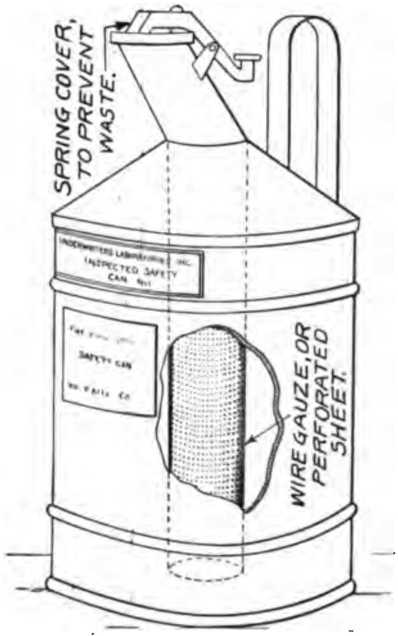


Fig. 3. Jacketed Draw-Off Valve.

The draw-off valve for this system, shown in Fig. 3, is also of jacketed construction and surrounded by the inert gas. It closes automatically by means of a spring (and pressure of the liquid) as soon as the draw-off lever is released, thus guarding against the valve being left open, accidentally.

Fig. 1. Man Pouring burning Gasolene from one Safety Can to another.



NON-EXPLOSIVE CAN FOR STORING INFLAMMABLE LIQUIDS.

Fig. 2. Type of 5-gallon Safety Can.

Fig. 3. Type of Small Safety Can.

Fig. 1 shows an actual demonstration of the results which may be obtained by the use of non-explosive cans for gasolene and other volatile oils. It is possible to pour the burning liquid from one can to another without fear of explosion.

Figs. 2 and 3 show two types of safety cans, many forms of which are on the market adapted to various kinds of service.

These cans are closed by a tight-fitting spring-cover, which prevents evaporation and waste of the liquid, thus effecting a considerable saving; furthermore this construction does away with the danger of explosive vapors being given off and causing an accident.

The safety feature consists of a tube of fine wire gauze or perforated metal, as shown in Fig. 4, extending downward from the opening. The liquid readily flows through this screen, but flame is not transmitted through it.

Fig. 4. Safety Plug for Tanks.

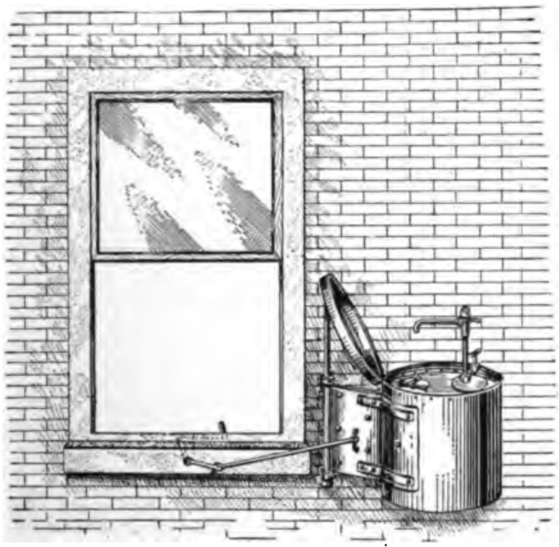


Fig. 5. Device for Storing Gasolene outside Building.

Where any considerable amount of gasolene or other volatile oil is used, underground storage tanks should be provided; the device shown in Fig. 5, however, which may be attached to the wall outside a window, is suitable for storing small quantities.

Fig. 6 shows an ordinary 1-gallon oil can which exploded, covering the man using it with burning alcohol. This accident would not have occurred if a safety can had been used.

Fig. 6. Exploded Can.

which is in good metallic connection with the pump at one end and the shut-off nozzle at the other end, or with bare copper wire inside of the hose with like connections at both ends.

Shut-off nozzles at the end of hose lines should be fitted with copper chain to rest on the car tank in metallic connection during filling, or with a metal clamp serving the same purpose.

The passage of gasoline through a chamois skin strainer has been found to generate electricity which is collected in the metal parts of the funnel in dangerous intensity, and the substitution of a funnel with a strainer of 80 or 90 mesh wire which will exclude water is recommended.

Safety lies in maintaining good metallic connection between the storage tank and the tank of the motor vehicle during the process of filling, so that all electricity generated may readily pass off to the ground as fast as generated.

Fire Extinguishing

Steam or other gaseous non-supporters of combustion, which can be turned on by valves located outside the enclosure, room or building in which an oil fire occurs, may often be advantageously provided. In some cases it may be practicable to have the arrangement such that steam is turned on automatically in case of fire or explosion. (See Fig. 7, P. 355.) Vats, tanks, etc., may be protected by doors operated by fusible links (see Fig. 3, P. 355) or by sand-boxes released by fusible links or by hand. (See Fig. 5, P. 333.)

The provision of chemical extinguishers and boxes of sawdust (preferably mixed with bicarbonate of soda as mentioned on Page 335) conveniently arranged for instant use, is also desirable. (See P. 333.)

Exits

At least two means of escape should be provided from all rooms in which quantities of inflammable liquids are used or handled. These exits should be remote from one another and so arranged that they would not be cut off by fires in dip-tanks, mixing-kettles, saturators, etc. Vats, pans, kettles, and similar vessels should be provided with covers which are kept in place as much of the time as possible.

Empty containers for inflammable liquids, such as drums or barrels, should have plugs, bungs, or other form of closure replaced as soon as they have been emptied of their contents.

Signs prohibiting smoking and the use of matches or open lights of any sort should be posted on doors of buildings where inflammable liquids or gases are present.

Before any one enters tanks or other containers of inflammable liquids for cleaning, repairs, etc., they should be thoroughly ventilated and blown out with steam or air. The presence of two persons, when such work is being done in locations where there is any possibility of asphyxiation, should be required. Safety belts and ropes may often be used advantageously for such work. (See Fig. 3, P. 277.)

Rules outlining safe methods of operation, cleaning and repairs, also plans to be followed in case of fire or other emergency, should be prepared. These rules should be posted permanently in the workrooms or given to the employees individually in writing. It should be definitely ascertained that employees are thoroughly familiar with the rules.

INDUSTRIES USING SMALL QUANTITIES OF INFLAMMABLE LIQUIDS

Where the use of gasolene, benzine, and similar liquids is merely incidental to the operations in a plant, as in shoe factories, printing establishments, etc., the main supply of liquid should be stored outside the buildings, preferably in underground tanks, and small quantities only should be brought into the buildings for immediate use.

For this purpose approved safety cans only should be used. Safety cans are those which are protected in such a manner as to prevent danger of the container exploding in case the vapor should be ignited at the opening. (See Fig. 1, P. 357.) Cans should be equipped with a tight-fitting cover to prevent evaporation or spilling, but suitable provision should be made to release the pressure and permit the contents to burn without explosion in case the can should be overheated.

Any portion of the supply which is brought into the workrooms and not used should be returned to storage at the end of the day.

CHAPTER 46

SAFETY EDUCATION, BULLETINS, SIGNS, ETC.

NEED OF SAFETY EDUCATION

SAFETY inspectors are frequently asked the following question: —

"How can you prevent this kind of accidents?"

The questioner then describes an accident for which the injured man himself was more or less glaringly to blame, with an air that clearly indicates he thinks the question of accident prevention has been shown to be preposterous; he feels that there is no answer to his query.

But there is an answer, and it is found in two words, — "safety education."

No one who has given the matter careful study believes that *all* industrial accidents can be prevented. After every possible precaution has been taken there will remain a material percentage of accidents that are inevitable, and which we cannot hope to eliminate. (See Chapter 3.) However, many of the accidents now attributed to carelessness can be prevented through safety education.

By safety education is meant the gradual training in care and caution of the entire personnel of a given plant or industry, including not only the workmen but the manager and other officials as well. So long as the chief executive of any concern treats accident prevention in a light or trivial manner, the majority of his foremen and workmen can be depended upon to do the same. They will be reckless and careless, and accidents will result from this very attitude.

It must be brought home to every one that an accident is a serious matter, and that the death or permanent injury of a workman casts a stigma on those responsible for it, if it could have been avoided. The workmen must be made to realize that the accident prevention campaign is for their benefit; that inevitably they are the ones who suffer most from accidents; and that it is greatly to their advantage to coöperate in this work by using the safeguards and upholding safety regulations. Every one is prone to take chances, but every chance-taker loses sooner or later; all employees must come to a realization that they cannot afford to lose even *once* when the question of human life is at stake.

METHODS OF SAFETY EDUCATION

The Formation of Safety Committees among the workmen is one of the most effective methods of safety education. (See Fig. 2, P. 360.) Where such committees are organized and maintained in accordance with the plan outlined in Chapter 47, they result, in the course of time, in the development throughout the working organization of a body of wide-awake men who are genuinely interested in looking out for their own safety as well as that of their fellow-workmen. The value of such an influence is apparent.

Accident Pictures

Another effective method of education in accident prevention involves the use of pictures. (See Fig. 3, P. 361.) This is of special value in dealing with ignorant workmen or foreigners who cannot read English, but it is also helpful in interesting those who are educated. The eye quickly grasps and impresses upon the mind the lesson of an accident picture, where a written description might fail to command attention.

The use of pictures in this way has been adopted in various forms, ranging from the simple photograph of a man contemplating the goggles which saved his eyes, to the film of moving pictures showing the cumulative effect of carelessness as a cause of accidents.

Many variations of the scheme are possible,

Fig. 1. Safety Sign at Plant Entrance. (National Tube Company.)

Fig. 2. Mill Safety Committee. (Neenah Paper Company.)

Foreign languages, as well as English, are used in the sign illustrated in Fig. 1, as shown in the smaller pictures underneath.

In plants having female employees it may be advantageous to have some of them serve on safety committees, as indicated in Fig. 2.

Fig. 3. Buttons, Caps, Paper-Weights, Calendars, Combs, Mirrors, Watch Fobs, Cigars, Pencils, and other articles given to Members of Safety Committees, and for Safety Records, etc. (Illinois Steel Company.)

Fig. 1. Bulletins posted in Frame.

Fig. 2. Bulletin-Board on Side of Building.*

On this page are shown typical bulletins which have been used to interest and educate workmen in the value of safety precautions.

Pictures used in this way often carry conviction where other methods fail to do so.

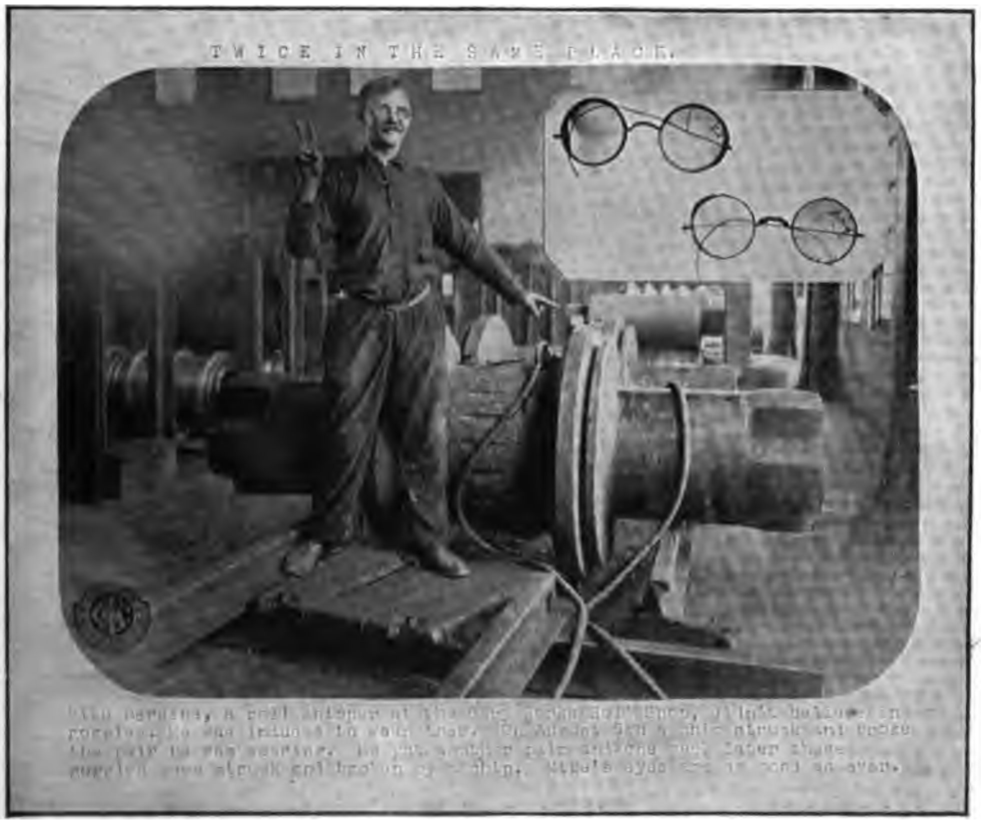


Fig. 3. Safety Photograph posted in Bulletin Form.†

* Courtesy of American Steel Foundries Company. † Courtesy of Illinois Steel Company.

STAIRWAY ACCIDENTS

CARELESS WAY

RESULT

Many Persons are Killed or Injured Every Year by Falls Down Stairways

Keep Your Hand

CORRECT WAY

On The Rail!

Model Safety Bulletin. (Actual size of this Page, 8½"×11".)

but one of the most important objects to be gained by the use of pictures is that of securing a graphic representation of the scene of actual accidents, particularly for the benefit of those who consider such accidents impossible.

Safety Bulletins are a valuable element in safety education. These bulletins cover such subjects as safe methods of doing work, photographs showing how accidents have occurred, charts giving reduction in accidents effected by safety work, the use of goggles and other forms of protection, danger from blood poisoning, unprotected machinery, nails, etc., etc. (See Pages 361 and 362.)

Safety Talks or lectures (with or without lantern slides) may also be used advantageously. Some concerns have given such talks interspersed with vaudeville or other amusements, so as to provide a pleasing form of entertainment for their employees.

In Learning to Read and Write, foreign workmen may be given valuable training in accident prevention, through the use of safety primers prepared by the so-called "Roberts" method. (See Page 403.)

SAFETY SIGNS AND SLOGANS

Another effective plan for educating the workmen and familiarizing them with accident hazards is found in the use of safety signs and slogans. These are of two distinct kinds, — the sign calling attention to a specific danger, — and the slogan which gives some general truth or striking observation bearing on the accident hazard.

Safety Signs

It scarcely seems necessary to state that a

Sign No. 1. Size, 7″ × 9″.

warning sign cannot be considered as a substitute for a positive safeguard, where the latter is practicable; or that merely posting a sign relieves the employer from further responsibility. The courts have repeatedly ruled that consistent efforts must be made to enforce general instructions of this sort, with disciplinary measures where necessary, before such instructions will be considered as placing the responsibility for their neglect on the employee.

Signs may do good service, however, in keeping safety rules constantly before the workmen, and in calling attention to particular hazards which might otherwise be overlooked.

For making these signs, enameled steel plate gives excellent results, as it is practically indestructible under ordinary conditions, and can be quickly wiped clean if it becomes obscured by dust or dirt.

A safety sign which has been used extensively is reproduced above, and shows the standard color and arrangement which have been adopted by some of the large manufacturing concerns of this country. This sign gives a striking effect in a plant, and it is hoped that the red disk will become as generally recognized as the red-cross sign, so that it will have a definite meaning to workmen of all nationalities, whether they understand English or not.

Data on a few characteristic signs, giving standard wording and sizes already in use, is contained in the following list: —

Sign No. 3. Size 10" × 12".

No. 2. "WARNING! Employees working around engines, moving or revolving machinery, shafting, etc., are warned against the danger, and are prohibited from wearing loose or unbuttoned jackets, blouses, shirts, torn clothing, long neckties, etc. Always wear over-all jacket tucked into trousers or under the over-all bib." Size, 8½" × 11".

No. 3. "ELEKTRIKA." (See cut.) This sign is recommended for marking high-voltage electrical equipment, and it is one which should be universally understood.

No. 4. "DANGER! Do not touch. Keep away." (Five languages, — Polish, Slavish, Croatian, Swedish, and Italian.) Size 12" × 14". For ordinary low tension electrical apparatus, this sign is recommended; it has a white band about 3" wide across the top, marked with red lightning flashes.

No. 5. "DANGER! Do not ride on elevator. Use stairway." Size, 36" × 14½". (Five languages.)

No. 6. "NOTICE. Every employee must wear goggles while babbitting, and goggles or face-mask while chipping, etc." Size, 7" × 9". (Note. This sign may be worded to suit conditions; where men who work at emery-wheels are involved, the word "grinding" may be substituted for "babbitting" or "chipping," etc.)

No. 7. "NOTICE. All hammers, chisels, punches, etc., must be kept in good condition to avoid danger from flying chips or defective handles." Size, 7" × 9".

No. 8. "MOTOR STOP. In case of emergency, pull cable." (Or "push button," etc.) Size, 9" × 4".

No. 9. "ELECTRIC ENGINE STOP. In case of emergency, push button 25." Size, 9" × 4½".

No. 10. "ENGINE STOP No. 4." Size, 3" × 4".

No. 11. "WARNING! Will not clear man on side of car." Size, 20" × 12".

No. 12. "DANGER! All employees must keep out." Size, 20" × 10". (Two languages.)

No. 13. "DANGER! No thoroughfare." Size, 12" × 18". (Five languages.)

Safety Slogans

Safety slogans have been used extensively in many manufacturing plants as a part of their educational campaign. Sometimes these slogans are shown in an illuminated sign placed at the entrance to the plant or some other prominent location. (See Fig. 1, P. 360.) They may also be made up in enameled steel plate as already mentioned for safety signs, or they may be printed on cloth or cardboard where they are of a temporary character.

The National Safety Council recommends that safety slogans or signs for educational purposes be in white letters on a green background, in order to distinguish them from warning signs.

A great variety of slogans have been used, of which the following are representative:* —

(1) Always give safety the first consideration.
(2) Do not fail to notice all danger signs, and, if possible, see that no one disregards them.
(3) Don't wait for the other man to report a dangerous condition; do it yourself.
(4) Warn a man when danger is near. He may know all about it; if so, no harm is done; if not, you may save him from injury.
(5) Remember that a loose sleeve, coat or tie may pull you into a machine.
(6) If you remove a safety device for repair work, put it back for the next man's sake.
(7) Don't join the one-eyed men who refused to wear goggles when exposed to flying chips.
(8) Don't use punches, chisels or hammers with burred heads or weak handles.
(9) Remember that men have been caught and killed on a smooth revolving shaft.
(10) Don't leave something in a passageway for the next man to fall over.
(11) Always "keep out from under" when moving heavy objects.
(12) Be sure you have a suitable ladder and place it firmly, before going up.
(13) To be careless, thoughtless or reckless means injury sooner or later to yourself or others.
(14) The coöperation of all employees in our efforts to prevent accidents is earnestly requested.
(15) We will welcome suggestions from employees on anything of a dangerous nature.
(16) Carelessness as to the safety of yourself or others will be sufficient cause for dismissal.
(17) A preventable accident is a disgrace to the foreman in whose gang it happens.
(18) Don't put off until to-morrow to make that safety suggestion you have in mind. It may save some one a serious accident.
(19) To avoid accidents to yourself and others, in case of doubt take the safe course.
(20) Beware of blood poisoning. A scratch may cause it.
(21) It takes less time to explain why you were late than to make out an accident report.
(22) Always bend nails down before throwing boards aside. Many serious injuries result in stepping on protruding nails.
(23) If you find a board on the ground with nails projecting, stop long enough to turn it over, with the ends of the nails down.
(24) Investigate every accident that happens in your gang, and try to prevent an accident occurring in a like manner.
(25) Do not pile material so that there is danger of its falling. You may be the man hurt if you do.
(26) Uncovered pits are dangerous. When you have to remove a pit cover, always see that it is replaced before you leave.
(27) All injuries, no matter how trivial, should be immediately reported and receive the necessary attention; it is neglect of the small injuries that makes trouble.
(28) You cannot afford to take chances. Play safe!

* A number of these slogans have been taken from a list compiled by the National Safety Council, to whom indebtedness is hereby acknowledged.

CHAPTER 47

INSPECTION

In carrying on an accident prevention campaign in any plant, the organization of a local inspection service within the plant is of the greatest value. This is effective, not only from the standpoint of eliminating accident hazards, but also from that of educating the personnel of the working forces along accident prevention lines.

ORGANIZATION

Whether a plant be large or small it is very desirable to have a definite organization, with a regular time allotted for making inspections; otherwise the work is likely to be done in a haphazard, inefficient manner, and the interest of the men will soon lag.

The exact organization and method of carrying on safety committee work will necessarily vary according to local conditions. The following suggestions, however, cover the important features which may be embodied in such work.

The organization should consist of: —

1. General Committees.
2. Workmen's Committees.
3. Safety Inspectors.

In a large plant (say 2,000 or more employees) each of these elements should preferably be represented. In smaller plants the organization may be reduced to suit conditions, the minimum for the smallest plant being a combined general and workmen's committee consisting of about three individuals.

The plan and scope of the organization may be outlined as follows: —

The General Safety Committee should consist of three or more persons, such as Ass't. Superintendent, Master Mechanic, Chief Electrician, and Department Heads. It should

(A–1) Make not less than one general inspection of the plant per month, with a written report of necessary safeguards or improved safety practices, this report being preferably signed by each member of the committee.

(A–2) Pass on all recommendations to determine their practicability and advisability. (For this purpose, meetings should be held at intervals of not more than one month.)

(A–3) Familiarize its members with all serious accidents, for the purpose of eliminating similar accidents in future.

(A–4) See that green hands are properly instructed as to the hazard of their work, and that men in their department are educated in safety practices, through the use of bulletins, printed rules, etc.

(A–5) Look after work covered in items C–1, C–3, C–5, C–7 and C–8, where there is no safety inspector.

The Workmen's Committee should consist of three (or four) members, one of whom acts as Secretary and keeps notes of the inspections. Where there is a local safety inspector, it is suggested that he serve as Secretary of the Workmen's Committee. This Committee should

(B–1) Make not less than two thorough inspections of the plant per month, with written report (or reports) of recommendations for safeguards or improved safety conditions which they consider desirable, such reports being signed by each member of the committee (or committees).

These committees should look out for such conditions as those mentioned in C–4, and C–5.

The secretary of the committee should preferably be on it permanently, or for at least six months or a year at a time, in order that one member of the committee may become thoroughly familiar with the general lines of safety effort which are started and thus be able to direct the work of the committee more advantageously. The other members should be changed at intervals of about once per month, in order to give as many men as possible the benefit of this experience. If weekly inspections are made, every one serving on the committee will thus make four inspections during his membership.

Upon leaving the committee each person who has served on it should be requested to consider himself a permanent member of the safety organization, to be constantly on the lookout for danger points, and to feel free at all times to report any item which he believes will reduce the accident hazard. In submitting names from which the members of these committees are to be selected, those who are most alert and capable should be chosen, so as to make the time spent in this way count to the greatest advantage.

In large plants containing several thousand men, two or more workmen's committees are desirable. In a representative organization with about 30,000 employees, approximately 700 served on the various safety committees last year.

In making up these committees, men from the rank and file (say a machinist, an electrician, and a machine operator) should be chosen, since they are the ones whom it is most difficult to reach by a plan of safety education. In order to impress them with the fact that their employers are in earnest, and consider this work really important, it is desirable to have some one in authority, such as the superintendent of the plant, instruct them when starting out, and express appreciation of their work when they are through serving on the committee.

The Safety Inspector should preferably devote all his time to safety work. Where the plant is not sufficiently large to justify this, he may have other duties, such as draughtsman, mechanical foreman or efficiency engineer, devoting a regular portion of his time to safety inspections. The safety inspector should

(C–1) Follow up general lines of outstanding safety work and keep records of same.

(C–2) Make general inspections of plant and machinery at intervals, with written recommendations for necessary safeguards or safety precautions.

(C–3) Make (or arrange for), regular inspections of special equipment, such as elevators, cranes, etc., with written records of each inspection.

(C–4) Inspect for maintenance of safeguards, general order and arrangement of materials, cleanliness, lighting, etc.

(C–5) Look after fire conditions, blocking of exits, lack of water in fire pails, etc.

(C–6) Investigate and report on all serious accidents, and keep record of accidents prevented.

(C–7) Standardize safeguards for the plant or plants under his jurisdiction.

(C–8) See that drawings and specifications for the purchase of new machinery cover the guarding of dangerous features, such as gears, sprockets, couplings, etc., and inspect new machinery before it is placed in operation to see that the necessary safeguards have been provided.

The personal qualifications of a safety inspector are very important. He should have a good knowledge of machinery, and resourcefulness in solving the safety problems which arise; above all he should be able to work with the other employees and secure their coöperation, without arousing antagonism. Safety recommendations are likely to be considered as a form of criticism by those to whom they are made, and it is essential that controversies and disagreements be avoided if this work is to be carried on successfully. It must be held up as something mutually advantageous for all concerned, in which all are working together to a common end, — viz., the avoidance of the suffering and loss which result from accidents.

Inspection of Special Equipment

Certain kinds of equipment, such as hammering tools, shop equipment, cranes, engines, elevators, etc., should be given a detailed inspection at frequent intervals, in addition to the general supervision which they otherwise receive. Where there is a regular safety inspector at a plant and the plant is not too large, it may be possible for him to make these inspections, otherwise a member of the mechanical or engineering force may be specified for this work, making inspections about once per week, in addition to his other duties.

Inspection Reports

The results of these inspections should be reported in writing; this record is of value even though recommendations are not contained in every report, as it indicates the conditions found by the inspector and may be of value for reference purposes if an accident occurs.

It is well to have the reports pass through the hands of some higher official, after the inspector has made them out. They can thus be checked up to make sure that the inspections are being made regularly and that the reports are not being neglected.

Numbering Recommendations

It is advisable to have all safety recommendations for a given plant numbered in a consecutive series from 1 up, regardless of the source from which they come; where this is done the total number of recommendations which have been made since the work started is indicated at all times by the numbers on the latest report. Furthermore, in checking up outstanding recommendations, the size of the serial number indicates immediately whether the recommendation is an old one or not.

Where it is desired to keep a record of the cost of safety work, as is usually the case, the serial numbers can be used for identification purposes, and the cost of each item can be kept under its proper number.

Many expedients for stimulating the interest of safety committees may be used.

If separate plants are controlled by one company, it is well to have "Inter-mill" inspections at occasional intervals (say once in six months), to arouse a spirit of competition in safety matters.

Each man who serves on the committee may be given a small badge or button which he can wear to indicate his connection with the safety organization. Other articles such as match safes, watch fobs, paper weights, etc., may be used also. (See Fig. 3, P. 360.)

Safety committees have already been formed in several hundred industrial concerns in this country, including steam and electric railways, mines, and manufacturing plants of widely diversified character. These committees have thoroughly proven their value, both from the standpoint of recommendations submitted and that of safety education of employees. (See Chapter 46, P. 359.)

Inspection Forms

Where safety work is handled as outlined above, the use of certain forms will be found advantageous; the following have been developed under practical working conditions, and are reproduced here in the belief that they will be of value to others who require similar forms.

Form for Writing up Recommendations

..............COMPANY........WORKS.

Safety Recommendation,....Dept., Serial No.....
Work covered.................................
....

Recommended by.............................
Date Inspection was made ....
Date Recommendation was approved............
Assigned for Attention to......................
Date Work reported complete...................
Completed Work approved by ....
Remarks: ....
....

This form, in a standard filing card size (preferably 4" x 6"), may be used for writing up the individual recommendations. An original and a carbon may be made, the former being kept by the man who is following up the work and the latter being given to the mechanic or foreman who is to carry out the recommendation. These cards may be kept in a small filing case, and the number on hand at any time shows immediately how many items are outstanding as each card contains but one recommendation.

After the recommendation has been completed, the carbon copy is returned; the work should then be checked up to see that it has been carried out satisfactorily, and the card may be filed away as a permanent record.

The information contained on this card will enable the person having oversight of the safety recommendations to quickly determine the status of each item at any time.

Other Forms for special equipment may be made up advantageously on $8\frac{1}{2}'' \times 11''$ sheets (the size of this page), which is a standard letter size and convenient for filing. A model form for the inspection of shop equipment, in actual working size, is shown on Page 370.

Additional forms for other types of equipment, as indicated, may be made up by substituting the following headings for those given in the shop inspection form: —

SAFETY INSPECTION OF CRANES

CRANE NO............

Drums, Chains, Cables and Hooks..............
Wheels and Flanges..........................
Brakes and Bells............................
Sweep Brushes and Bumpers..................
Track Clamps................................
Draw Bars and Push-Poles....................
Motors, Generators, Electric Wiring, etc.........
Foot-Walks and Railings.....................
Warning Signs...............................
Any Other Part not specified above.............
Does Operator consider Crane Safe?.............
Should Crane be shut down immediately until repaired?..................................

(This form is to be used for Traveling and Locomotive Cranes, Bridges, Gantrys, etc.)

SAFETY INSPECTION OF ELEVATORS

ELEVATOR NO............

Cables and Connections......................
Emergency Clutch and Ratchet................
Guides and Cage.............................
Automatic Stops.............................
Gates.......................................
Signaling Apparatus and Warning Signs.........
Counter-Weights and Attachments ....
Drive, Including Shafting, Belts, Pulleys, Drums, etc...
Operating Levers, Shifters, Valves, etc...........
Any Other Part not specified above ....
Does Operator consider Elevator Safe ?..........
Should Elevator be shut down immediately until repaired?..................................

SAFETY INSPECTION OF ENGINE APPLIANCES

ENGINE NO............

Automatic Stop; — Push Buttons...............
Speed Limit.................................
Batteries (Give Voltage)......................
Are Wires of each Circuit O.K.?...............
Railings, Toe-Boards, etc.......................
Butterfly-Valves.............................
Is Bracket or Collar on Engine Governor in Stopping Position? ....
Any Other Part not specified above..............
Does Engineer consider Equipment Safe?........

(Each Push Button should be tested, with man at throttle to prevent Engine shutting down where necessary.)

SAFETY INSPECTION OF TRACKS, ETC.

DEPARTMENT...........

Warning Signs...............................
Tell-Tales...................................
Bumpers....................................
Tracks, Connections, etc.,.....................
Walks and Railings at Trestles................
Clearance of Piled Material...................
Scrap, etc., along Tracks......................
Any Other Equipment not specified ....
Foot-Guards at Switch, No. 1, 2, 3, 4, etc........

SAFETY INSPECTION OF LOCOMOTIVES

LOCOMOTIVE NO............

Lights and Whistle...........................
Bell and Ringer..............................
Foot-Boards and Running Boards..............
Grab-Irons and Steps.........................
Couplers and Brakes.........................
Safety Valves................................
Push-Poles and Switch Ropes ....
Sand Equipment.............................
Wheels, Tires and Flanges....................
Any Other Parts not specified above ....
Does Engineer consider Engine Safe............
Should Engine be laid up immediately until repaired? ....

SAFETY INSPECTION OF RAILROAD CARS

CAR NO............

Steps and Grab-Irons.........................
Couplers....................................
Brakes......................................
Running Boards.............................
Wheels and Flanges..........................
Any Other Part..............................

______________________ **COMPANY**

______________________ **WORKS.**

SAFETY INSPECTION OF SHOP EQUIPMENT. **DATE** ______________

SHOP NO. OR NAME				
Sledges or Hammering Tools				
Cold Chisels, Punches, etc.				
Ropes and Chains				
Blocks, Chain Falls, etc.				
Jacks, Air and Steam Hoists, etc.				
Pinch and Crow Bars				
Guards for Gears, Shafting, Drives, etc.				
Painters' Scaffolds, Rope and Tackle				
Any Other Equipment Not Specified above				
Is Any of This Equipment Unfit for Use?				

Designate Parts Inspected and found O.K. by "X."

Designate Defective Parts by a letter, using A, B, C, etc., and give explanation of Defect in blank space below.

INSPECTOR

This Form to be used for Machine, Blacksmith, Carpenter, Elect. Repair, Tin Shops, etc.

CHAPTER 48

EYE PROTECTION

CAUSES OF ACCIDENTS

DURING a period of approximately one year ending June, 1912, 593 eye injuries involving more than one day's lost time occurred in Massachusetts industries and were reported to the Workmen's Compensation Commission.* An analysis of these accidents shows the following classes of injuries which are of special interest on account of their bearing on safety devices.

Cause of Injury	*Total Accidents Reported*	*Loss of Eye*
1. Belting (broken belts, 3; blows from stick, 2).....	5	—
2. Electric Flash............	27	—
3. Abrasive Wheels	56	2
4. Hammering (pieces of hammer, chisel, chips, etc....	68	15
Flying tools or material)	33	5
5. Machine Tools (milling-machines, saws, etc.)....	16	—
6. Molten Metal............	47	4
7. Riveting	16	3
8. Water and Lubricator Glasses Bursting	7	1
Total ...	275	30

1. Accidents from broken belts are generally traceable to the use of hooks, lacing, etc., in making a joint, which do not develop the full strength of the belt. The use of "endless" belts with glued joints reduces this danger, and the installation of suitable belt guards, in addition, will practically eliminate it. (See Chapter 17.)

Replacing belts on pulleys by means of a stick is a dangerous practice, and one which has been the cause of many serious accidents. This practice should be discouraged, and if resorted to in case of emergency, the stick should be handled only by an experienced man, using extreme caution. (See Chapter 15.)

2. Accidents from electric flash can be largely reduced by enclosing live parts such as switches, fuses, starting rheostats, etc. (See Chapter 13.) Rules forbidding work on live circuits except in case of extreme emergency will also be effective in preventing many such accidents.

3. Eye injuries at abrasive wheels can be prevented by the installation of hoods, exhaust systems, and guards (see Chapter 23) as well as by the use of goggles. The latter should always be required where grinding is continuous, or nearly so.

4. Hammering, Chipping, etc. It will be noted that this class of work leads with a good majority in "Loss of Eyes." The use of goggles for chipping is probably the most important method for preventing accidents under this heading. (See Fig. 2, P. 376.) A good percentage of these accidents, however, is due to the use of tools with burred or "mushroomed" edges, and insistence on the workmen keeping their tools properly dressed will cut down such accidents very materially. (See Chapter 21.)

5. Machine Tools. It is possible to use a "chip guard" (see Page 205) to protect the eyes of men working on machine tools such as milling machines, shapers, etc.

6. Molten Metal. The use of goggles is very effective in reducing accidents of this class; a large number of cases are on record where goggles have saved the eyes of men working in foundries, or babbitting, etc.

7. Riveting. Here again the use of suitable goggles is practicable for the elimination of injuries.

8. Water and Lubricator Glasses. Glasses un-

* Accident data furnished by Massachusetts Commission for the Blind.

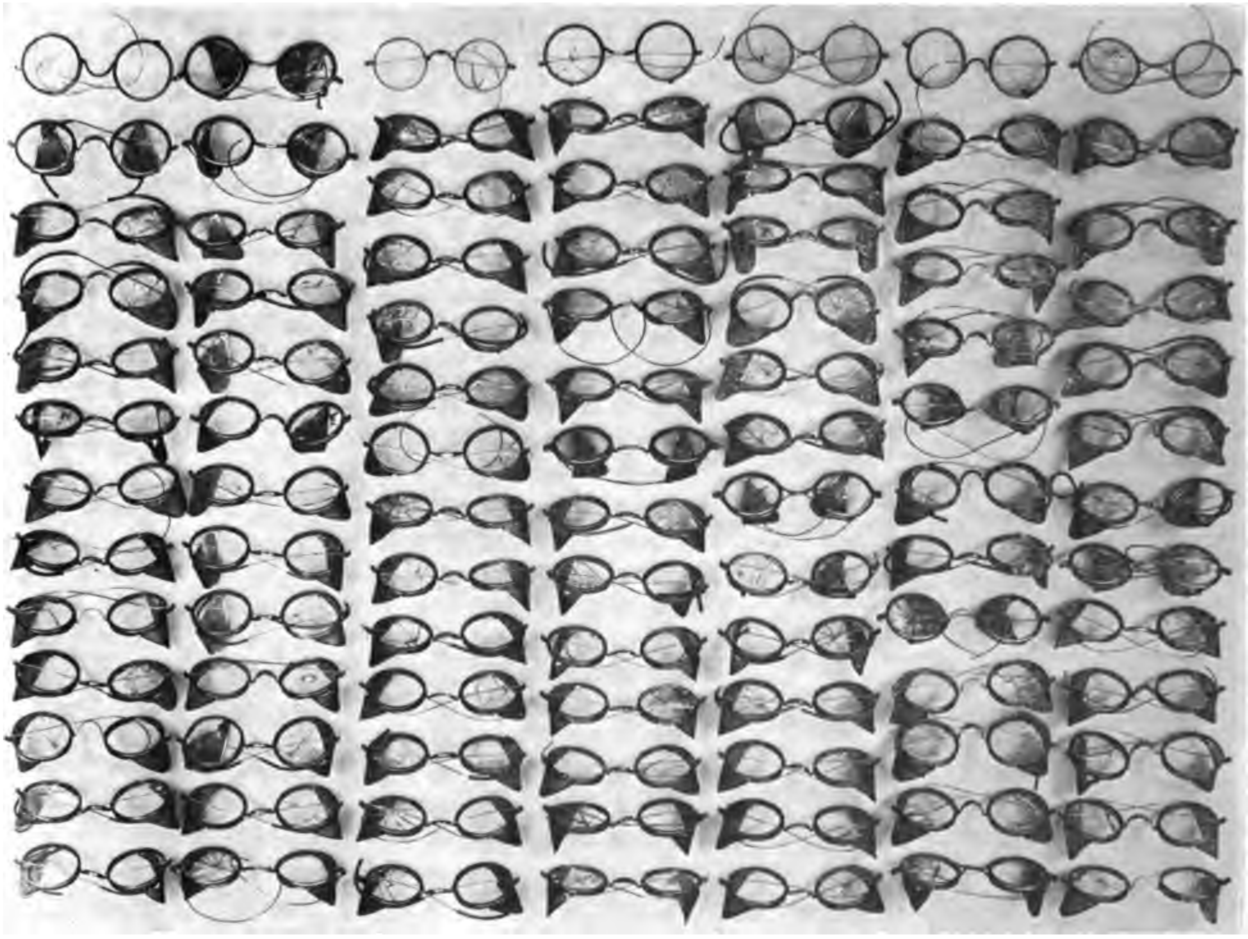


Fig. 1. Goggles broken by Flying Chips.*

Fig. 2. Chip caught in Goggles during Actual Work.*

Fig. 3. Goggles covered with Molten Babbitt.*

Fig. 1 shows approximately one hundred pairs of goggles broken by flying chips in plants of the American Steel Foundries Company during a period of three months. This furnishes convincing evidence that it is possible to get workmen to wear goggles for such service, and that it is worth while to do so.

The goggles shown in Figs. 2 and 3 undoubtedly saved the eyes of the man wearing them.

Men who pour babbitt, and those who constantly grind or chip castings, as well as machinists and other workmen who have a varying amount of this work to do, should be required to wear some form of eye protection.

* Courtesy of American Steel Foundries Company.

der steam pressure should be provided with guards which will prevent injuries in case the glass should burst. (See Chapter 11.)

Analysis of the 593 injuries reported, which include the loss of 63 eyes, leads to the conclusion that 275 of the injuries and 30 cases of loss of sight, or almost one-half the total, are preventable. This may be taken as fairly characteristic of the general nature of industrial eye injuries.

USE OF GOGGLES

It will be noted from this analysis that goggles are the principal agency for reducing eye injuries. Goggles have a wide range of application, being of value not only for such work as chipping, grinding, and babbitting, but also for whitewashing, dismantling buildings, etc., — in fact, for use in any place where there is danger of men getting particles of dust or other substances in their eyes.

Excellent results have been secured by a number of concerns that have conducted a campaign for the prevention of eye injuries. Among these probably the most striking reduction has been accomplished by the American Steel Foundries Company. In an article printed by the American Foundrymen's Association, Mr. W. H. Cameron, at that time Manager of the Casualty and Safety Departments of the company, states that 287 pairs of spectacles broken in service were collected from its various plants during the course of six months. Only three eyes were lost in all plants during a period of over twenty-seven months, by workmen to whom spectacles had been furnished.

Mr. Cameron describes these three cases as follows: —

In one instance the piece of steel penetrated the lens with great velocity, and entered the eye of the workman. We believe that if the spectacles had not been worn a much more serious accident would have resulted. The second eye accident happened to a machinist before we had insisted on the use of the spectacles by this class of workmen; and the third eye injury happened to a chipper who temporarily was carrying his spectacles in his pocket instead of wearing them.

One need only glance at the pile of broken goggles to realize that numerous serious injuries must have resulted had the goggles not been worn. The following list gives a comparative statement of this company's experience for two and one half years, indicating a reduction of about 75% in the last six months as a result of its safety campaign.

July 1910 to Dec. 1910	6.5%
January 1911 to June 1911	2.8%
July 1911 to December 1911	2.8%
January 1912 to June 1912	2.5%
July 1912 to December 1912	1.6%

Goggle Construction

One of the reasons why goggles have not been used more successfully in the past is that satisfactory goggles were not available. Those intended for severe service, such as chipping, were mostly of foreign manufacture and more or less uncomfortable, inconvenient and unsanitary. The question of goggle design has been gone into very thoroughly, however, by American manufacturers during the past two or three years, and several types of goggles of excellent design and construction have been developed.

Especial attention has been given to making goggles which would be comfortable for workmen having widely different facial contours. This has been accomplished by providing flexible goggles which rest partially on the cheeks, thus distributing the pressure, — by the use of adjustable nose bridges, — and by making bridges of varying widths. These goggles are constructed entirely of glass and metal so they are thoroughly sanitary and when surrendered by one workman they may be sterilized before they are given to another.

The lenses of goggles used for chipping are made from tough, thick glass, which will withstand a heavy blow without breaking. They are held in substantially flanged rims, so that even though the lens is shattered the glass does not readily come out.

Breaking lenses

Repeated experience has shown that the eye closes so quickly that where the lens is broken and pieces of glass fly from it, the eye-lid is almost invariably shut; if any cut is received it is on the outside of the lid, and superficial in character. The goggles "give" somewhat under the impact of a blow, and the fraction of a second's time thus saved is sufficient to close the eye-lid and save the eye. Where the force of a flying chip is so great as to break a heavy lens of this kind, it is obvious that the eye-ball would be shattered, even though the eye-lid were closed, if no goggle were used.

At a recent safety exposition one of the goggle manufacturers gave a graphic demonstration of the resistive power of good lenses. Repeated blows from a plunger actuated by a strong spring often failed to even crack the glass. Many workmen have been reassured in this way, where they were at first afraid to wear goggles lest they should get particles of broken glass in their eyes.

Goggles for chippers should have screens at the side, preferably of wire gauze, to deflect particles which may come from this direction. (See Figs. 1, 4, and 5, P. 375.)

For work in dusty or gaseous locations a tight-fitting goggle is needed. Such goggles may be obtained, with rubber mountings which conform closely to the contour of the face. (See Fig. 2, P. 375.)

For the use of grinders a heavy glass is not required, but the lens should be wide (say about $2\frac{1}{2}''$), so as to give a good field of protection. (See Fig. 3, P. 375). Where there is only one grinder side screens on the goggles are superfluous, but where two or more grinders are located side by side such screens may be of value. Extra lenses should be kept on hand, as emery dust soon pits or scratches the surface of the glass, necessitating its replacement.

The harmful effect of continued exposure to emery dust in the eyes is not confined to the immediate injury. Gradual deterioration of vision may result from small abrasions on the cornea or "lens" of the eye, caused by sharp particles of dust. These abrasions leave permanent scars which blur and impair the vision.

It is now feasible to insist upon workmen wearing goggles, in view of the improved conditions already described, where this could hardly have been done a few years ago. In order to get the best results, however, the men should feel satisfied and use the goggles voluntarily. The matter should be carefully explained to each workman, individually, and he should be shown different types of goggles from which to select the one he likes best.

If, after a reasonable time these methods fail to produce results, stronger steps should be taken. In the article already mentioned, Mr. Cameron states that cleaning-room workmen employed by his company were asked to sign a contract, under the terms of which they agreed to wear the goggles constantly and in case a man were injured while at work without goggles the company was freed from responsibility for the accident.

For casual chipping, such as that done at intervals by the operator of a machine tool, it is more difficult to enforce the use of goggles, but it is believed that even this pays in the long run, as there is occasional loss of sight from accidents occurring in such work.

A suitable carrying case should be provided, together with a cleaning cloth, so that the goggles may be properly taken care of. "Sweat pencils" are available which may be used to clean the lenses and prevent the formation of moisture for several hours, thus removing another ground of objection. Where the workman does not have normal vision, the goggle lenses should be ground to an oculist's prescription so as to give the proper refraction.

In Open-Hearth Steel Works and other locations where furnaces carrying high temperatures are in use, the men who tend these furnaces should be provided with suitable colored glasses. Such glasses are on the market with lenses of a color especially adapted to the elimination of harmful ultra-violet rays, which may pass through ordinary "smoked" glasses and injure the sight of the wearer.

For Electric Welding a helmet should be provided, or a guard may be suspended from overhead supports in such a way that the work-

Fig. 1. Safety Goggles.

Fig. 2. "Gas-Tight" Goggles.

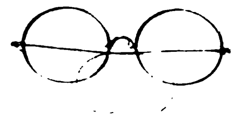


Fig. 3. Goggles for Grinder.

Fig. 4. Goggles for Chipping, etc.

Fig. 5. Another Type of Goggles for Chipping, etc.

Fig. 6. Metal Carrying Case.

Fig. 7. Leather Carrying Case. and Cleaning Cloth.

Figs. 1, 4, and 5 represent three standard makes of goggles for chipping and other heavy service. The goggles shown in Fig. 1 are made with various widths of nose bridge; in Fig. 4 the nose piece is carried on a spur, so it can be readily adjusted; in Fig. 5 the bridge can be bent so as to adapt the goggles to the face of the wearer, the weight resting on the sides of the nose, and cheeks, rather than on the bridge. In these ways provision has been made for the comfort of the man wearing the goggles, — an important matter if his co-operation is to be secured.

The goggle shown in Fig. 2 is known as the "gas-tight" goggle, since it has rubber mountings which conform closely to the face of the wearer, thus giving good protection against noxious vapors, fumes, fine dust, etc.

Fig. 3 shows goggles with large plain lenses, suitable for emery wheel grinding. Such lenses should be about $2\frac{1}{2}''$ in diameter, so as to give a wide field of protection.

Carrying cases, as shown in Figs. 6 and 7, should be provided for keeping the goggles clean. Lenses should be of tough glass, carefully ground, and giving no "wavy" effect when they are moved back and forth in front of the eye.

In order to avoid danger from contagious eye diseases, each man should have his own goggles, and case with cleaning cloth. (Fig. 7.)

Fig. 1. Canvas Screen for Chipping.*

Fig. 2. Men who Chip Castings Wearing Protective Goggles.*

Fig. 3. Burred Hammer, — a Common Source of Eye Injuries.*

This screen (Fig. 1) protects both chippers and adjacent workmen, since chips either stick in the screen or fall "dead."

Fig. 4. Face Mask of Fine Wire Fabric.

Fig. 5. Hood with Colored Glass Window to Protect Eyes of Electric Welder.†

Fig. 6. Hammer Properly Dressed, — An Important Safety Precaution.

* Courtesy of American Steel and Wire Company, subsidiary of U.S. Steel Corporation. † Courtesy of Illinois Steel Company, subsidiary, of U.S. Steel Corporation.

man can look through it. The eye openings should be protected by colored glass, four layers of two blue and two red sheets, alternately arranged, being commonly used.

PROTECTIVE SCREENS

Screens of canvas, stretched on a frame and mounted on a suitable stand, should be provided where castings are being chipped. These are of value not only in protecting other persons from flying chips, but they safeguard the chipper also; a piece striking such a guard, either sticks in it or falls "dead" where it might otherwise rebound with considerable force.

The indiscriminate removal of particles from the eye by fellow workmen should not be permitted; many cases of eye injury or infection have resulted from this practice. Where there is a hospital attendant constantly on duty at a plant the men should be instructed to go to him whenever help of this kind is needed; where there is no hospital attendant some one should be designated for this duty and instructed in the proper methods to be employed. Any serious eye cases should be taken to an oculist for attention.

CHAPTER 49

HOUSEKEEPING, HAND LABOR, ETC.

GENERAL care and orderliness, or "housekeeping" as it has been designated, is a most important factor in the prevention of industrial accidents. Eight thousand four hundred and eighty-three accidents, 66 of them fatal, were reported to the Massachusetts Industrial Accident Board in one year from falls (see P. 10); nearly one thousand of these accidents were falls into holes, pits, etc., or over obstructions on the ground or floor; 1,385 were caused by slipping or tripping on the floor level. This is convincing evidence, if any were needed, of the necessity for keeping passageways, floors and platforms free from tools, materials or other obstructions, and for the avoidance, so far as practicable, of moisture or other conditions which may make the floors slippery. Pits or other openings in the floor or ground should be provided with covers or railings, to prevent danger of persons falling into them. (See Figs. 3 and 4, P. 308; also 1 and 3, P. 379.)

Material falling from overhead caused 1,672 accidents, 8 of them fatal. Nails in boxes, barrels or other objects caused 1,643 accidents, and nails on the floor or ground 1,819. (See Fig. 2, P. 379.)

Most of these accidents may be attributed to poor "housekeeping" conditions, and constant watchfulness on the part of all concerned is necessary for their elimination. Such accidents are, perhaps most of all, preventable through the safety education of the working force. (See Chapter 46.) Suitable barriers or guards for overhead platforms are of some assistance in preventing such injuries, as are also signs calling attention to the danger where overhead work is being done. (See Fig. 4, P. 379.)

Projecting nails should be removed from walls or columns within six feet of the floor, to prevent danger of persons striking them and being injured. Such projections at the level of the eye are particularly dangerous. Nails should not be permitted to lie around loose on the floor or projecting from boards, boxes, etc. All employees should be instructed to remove such nails, bend them down or turn them over, where they are lying with the points up.

Revolving Shafting should be kept free from waste, cords, etc., which may wind around it. Such materials should only be removed while the shafting is shut down, otherwise it may catch the hands or tools used in removing it and cause injuries.

Hand Labor caused 29,774 accidents, or almost one third of all those occurring in Massachusetts during a year. (See P. 11.) Here again the personal factor is the predominating one. The foreman or sub-foreman in charge of a gang of men must be constantly on the lookout to prevent workmen being caught by material, to see that proper tools are being used, etc. The workman also shares responsibility for these conditions, and is almost entirely responsible for avoiding accidents such as those caused by slivers, sharp edges, etc. (of which there were more than 11,000), and for strains from lifting (1,837 cases). (See Fig. 2, P. 381.) In some kinds of work the latter class of injuries may be reduced by providing special tools or appliances for doing the work, such as hoists or cranes for handling material, car movers (Fig. 1, P. 270), wheel trucks (Fig. 1, P. 381), etc.

Improper clothing is responsible for many accidents. (See P. 142 and Fig. 3, P. 210). Persons working about machinery should not be

Fig. 1. Courtesy of the American Steel Foundries Co. Fig. 2.

Figs. 1 and 2 show items which come under the general head of "housekeeping." Many persons are injured by falling into unprotected openings, or over objects carelessly left lying on the ground or floor. Protruding nails in boards and in the sides of boxes, barrels, etc., are another prolific cause of accidents. Constant care and co-operation on the part of all concerned are necessary for the elimination of these hazards.

Fig. 3. Courtesy of the Illinois Steel Co.

Fig. 4. Courtesy of the American Steel and Wire Co.

Fig. 5. Courtesy of the American Steel Foundries Co.

Fig. 3 shows a good guard for trap doors. When in use, the guide rods rest on a ledge at the front of the pit; when the door is closed, they swing down inside the opening.

Fig. 4 illustrates a warning sign used where overhead work is being done.

Fig. 5 shows portable gangways with permanent railings at the sides.

permitted to wear long neckties, loose jumpers, flowing sleeves or other loose clothing which may be caught in the machinery and draw the wearer after them. Women operatives should preferably wear tight-fitting caps. (See Fig. 4, P. 381.)

Finger-rings may be the cause of serious accidents. In some cases such accidents have occurred from a ring being caught on a rapidly moving part of a machine.*

For persons working about electrical equipment, a ring adds a material element of hazard. Where there might be little or no current-flow if the dry skin only touched a live conductor, a ring, and the moisture which gathers underneath it, form a path of low resistance which may result in serious shocks or burns from accidental contact with electrical apparatus.

Stools, chairs, benches, etc., if weakly constructed or allowed to get out of repair, may give way under the weight of persons using them, and cause falls which result in bad injuries. All such equipment should be of strong and rigid construction, and kept in good repair at all times.

PILING AND STORAGE OF MATERIALS

Wherever heavy materials are piled to any considerable height, as is commonly done in storehouses, warehouses, etc., there is danger of injury to workmen when the material is being placed or removed, unless this is done in an approved manner.

If the pieces stored are round, such as pipes, tubes, etc., special bars or stringers should be provided on which they may be placed in successive layers. These stringers should be constructed so as to guard against pieces rolling off the ends, and should preferably be of steel; if of wood they should be well constructed, of ample strength, and should be inspected at regular intervals to see that they are in good condition. (See Fig. 2, P. 382.)

Iron or steel bars can best be kept on a structural steel rack, the ends of the bars being visible so that they can be conveniently selected as required. (See Fig. 1, P. 382.)

The practice which is occasionally encountered, of piling heavy objects on temporary and poorly constructed wood platforms on overhead beams or trusses should not be permitted, where persons are employed in the space below. The wooden supports are likely to dry and warp so that the material will be disturbed and fall unexpectedly. All storage platforms should be of rigid and substantial construction, and if overhead, any exposed edges should be protected with barriers or railings so arranged as to make sure that the objects stored will be properly confined to the platforms.

In general storehouses where the articles are of various weights and sizes, those which are heaviest and most difficult to handle should be placed on the lower shelves; this is not only the safer arrangement, but it also saves labor in handling them. (See Fig. 3, P. 382.) Heavy objects or materials should be preferably stored on ground floors. (See "Overloading," Page 46.)

The kinds of material encountered in different industries vary exceedingly; while the question of safety is largely dependent on competent supervision by experienced foremen, it is well to have some definite rules prepared, outlining the best methods for handling the particular material in question.

The following instructions for piling brick and cement may be taken as characteristic examples of such rules; they were prepared by subsidiary companies of the United States Steel Corporation, viz.: the Illinois Steel Company and the Universal Portland Cement Co., to whom indebtedness for their use is acknowledged.

In Piling Brick the Following Rules should be observed: —

(*a*) Except in brick sheds, brick must not be piled higher than seven feet.

(*b*) The pile should be tied at every course with alternative courses of headers and stretchers.

* In one case of which the author has knowledge a ring on the hand of an engineer was caught by the T-shaped handle of an oil cup on the cross-head of an engine. The finger was almost torn from the hand. The ring was filed off by the surgeon in charge of the case, and later the finger had to be amputated.

Fig. 1. Truck for Carrying Wheels.*

The car wheel truck shown in Fig. 1 practically eliminates hazard in handling wheels. The height of this truck may be quickly adjusted for different sized wheels. Without such a device, crushed hands or feet, strains and other injuries may be received while handling wheels.

Fig. 2 illustrates a common hazard of handling heavy materials. Where these materials are lifted by hand, hernia or serious strains may result. Chain hoists (see Fig. 3, P. 169) or air hoists can often be used advantageously for reducing this hazard. (Air hoists should be provided with a check valve to prevent weight dropping in case the air pressure should fail.)

Fig. 2. Lifting Hazard.†

Untidy conditions, such as those shown in Fig. 3 are responsible for many falls, nail injuries, etc.

Tight-fitting caps and other clothing play an important part in the avoidance of accidents to female employees working about machines. Many injuries have occurred from loose hair or flying clothing of women workers being caught on shafting or in machines.

Fig. 4 shows suitable caps and outer garments, also goggles, worn by the female employees in a large industrial plant.

Fig. 3. Poor " Housekeeping " Conditions.‡

Fig. 4. Proper Clothing for Workers.§

* Courtesy of Boston Elevated Railway Company.
‡ Cited by the United Gas Improvement Company.
† Dennison Manufacturing Company.
§ General Electric Company.

Fig. 1. Iron Rack.*

Fig. 2. Skids for piling Heavy Kegs.*

Fig. 3. Poor Storehouse Arrangement.†

Fig. 1 shows a good arrangement for storing iron bars and structural shapes.

The use of skids as shown in Fig. 2 saves space, and at the same time gives good safety conditions. Metal bars, turned up at the ends, may be used advantageously in place of wooden skids, as they are not so liable to get out of repair. Some such arrangement is desirable for piling any round objects, such as pipe, shafting, kegs, etc.

Fig. 3 shows a dangerous arrangement found in a storeroom. The heavy sledges and wedges on the top shelf might easily be knocked or jarred off and injure some one. Wherever possible, heavy objects should be stored on the lower shelves, and light ones above.

* Courtesy of American Steel Foundries Company.
† Cited by The United Gas Improvement Company.

(c) When the pile is over four feet high it should taper back, from a point four feet high, one inch to each foot.
(d) In unpiling the taper should be maintained.
(e) Under no circumstances should brick be piled for storage purposes on scaffolds or runways.
(f) Tie strips of wood should be inserted wherever necessary.
(g) All foremen in charge of piling or unpiling brick will be held individually responsible for safety of the piles.

In Piling Cement the Following Rules should be observed: —

(a) Cement must not be piled more than ten bags high, except in storage built for such purposes.
(b) The first four end bags should be cross-tied in two separate tiers up to the fifth bag, where a step back of one bag in every five bags should be made. Beginning with the fifth bag, only one cross tier will be necessary.
(c) The back tier, when not resting against a wall of sufficient strength to withstand the pressure, should be stepped back one bag in every five bags, the same as the end tiers.
(d) In storage, when piled between and against walls of sufficient strength to withstand the pressure, no cross tiers nor step backs will be necessary, but bags should be piled with a slight incline against the back wall, the height depending on the strength of the wall.
(e) Cement bags in outre tiers should in all cases be piled with the mouth facing the center of the pile.
(f) When cement is removed from a pile, the length of the pile should be kept at an even height and necessary steps back every five bags, must be taken care of.
(g) All foremen in charge of piling or unpiling cement will be held individually responsible for the safety of the piles.

It should be borne in mind that unstable material such as sand may exert considerable side pressure upon walls or partitions against which they are piled. Building walls have been actually wrecked in this manner. Walls should accordingly be strongly reinforced, where such materials are stored to a considerable height.

The wearing of goggles, respirators, use of ladders and other precautions affecting the hazards of hand labor are covered in other parts of this volume. (See Chapter 48, also Page 307 and Page 311.)

CHAPTER 50

HOSPITAL AND FIRST-AID EQUIPMENT

HOSPITAL FACILITIES

WHERE a plant is sufficiently large to justify the expense, it is desirable to have an emergency hospital for giving prompt attention to injured workmen. (See Page 385.) Where it is impracticable to have complete hospital facilities, a suitable room may be fitted up for this purpose. "First-aid kits," containing the necessary materials for applying temporary dressings, etc., should be kept on hand in the smaller plants, as well as in the various departments of the large plant. (See Page 387.) Where there is no nurse or hospital attendant regularly on duty, some one should be trained in first-aid work, so as to minimize danger to an injured man before the ambulance or physician arrives.

Even where a plant hospital has been provided, it is often difficult to get the workmen to go to it for the treatment of slight injuries, such as minor cuts and abrasions. Prompt attention in these cases, however, is an important matter. Many deaths have occurred as a result of infection or blood-poisoning developing from trivial injuries. The trouble is that such injuries are commonly neglected until too late.

An excellent plan for handling such cases is recommended by the Conference Committee of the National Affiliated Safety Organizations. This consists in placing glass jars containing an assortment of first-aid material (see Fig. 3, P. 387) in the different departments, and designating some one located in each department to take care of this equipment and treat minor accident cases.

Since this person is constantly at hand and in close touch with the men of his department, the latter have little hesitancy in coming to him for attention and will do so where they might not take the trouble to go to the mill hospital.

The first-aid man, after each treatment, fills out a card giving such information as the name of the injured person, the character of the injury, date on which the injury occurred, etc. This gives a record that may be followed up by the surgeon or hospital attendant in the course of a day or two to see that the wound is healing satisfactorily.

MEDICAL SUPERVISION OF EMPLOYEES

Some concerns have gone even further and make a thorough physical examination of each employee. (See "Keeping Workmen in Repair," by W. Irving Clark, M.D., in "System," for September, 1913; see also Fig. 2, P. 387.) There is no doubt that excellent results can be secured in this way; it makes possible what might be termed "Preventive Surgery," which is closely akin to Accident Prevention, in that it may have a material effect in reducing the number of accidents which occur in a given plant.

By this method it is possible to detect physical defects in the workmen and avoid placing them at tasks where these defects may be increased, or may result in accidents. For example, — the man with a weak heart should not be made to work at a furnace into which he might fall in a fainting spell; the man whose lungs are affected should not work where there is excessive dust; the man suffering from hernia should not be required to lift heavy objects; the man with defective vision should not be permitted to operate a hot metal crane, where a slight miscalculation on his part may upset a ladle and endanger many lives.

The following example may be cited as showing the actual experience of one concern which has been making physical examinations of applicants for positions with it. Out of 666

Fig. 1. Plant Hospital.*

Fig. 2. Operating Room in Plant Hospital.*

The proper care of injured men after an accident occurs is next in importance to preventing the accident; the necessary facilities for supplying this care promptly may be an important factor in minimizing the results of the injury.

Figs. 1 and 2 are photographs of a hospital located just outside a plant entrance, thoroughly equipped for giving immediate attention to injured employees.

Fig. 3. Emergency Rooms in Industrial Plant.

* Courtesy of American Steel and Wire Company, subsidiary of United States Steel Corporation.

persons examined, 85 were rejected for the following reasons:

Active tuberculosis	11
Suspicious "	10
Tubercular glands of the neck	2
Heart trouble	7
Anæmia and Chlorosis	12
Epilepsy	2
Diphtheria	1
Bright's Disease	9
Cirrhosis of the liver	1
Venereal disease	7
Hernia	4
Physical defects	10
Sick, no definite diagnosis	9
Total	85

In addition to adapting the men to the work for which they are best suited, personal advice may be given by the surgeon conducting the physical examination, which will aid materially in improving or overcoming the individual defects encountered, thus avoiding the progressive effects of disease or ill health. In some companies bulletins are regularly published giving general notes on health and hygiene for the benefit of their workmen.

Estimates of the cost of breaking in a new workman run anywhere from fifty dollars to three hundred dollars per man; where a trained employee is out on account of sickness or for any other reason, it generally means shutting down machines and loss of product for the manufacturer; a man in good health will do his work better and turn out more product than the same man suffering from ill health or disease; furthermore, the man in good health is less liable to accident.

Each of these items involves a definite element of cost, and taken together they justify a considerable expenditure for medical supervision, making such supervision desirable from the business, as well as from the humanitarian, standpoint. (See Fig. 1, P. 387.)

FIRST-AID EQUIPMENT. (See Figs. 3 and 4, P. 387.)

The following equipment, required by law in Massachusetts for factories or shops using machinery and for mercantile establishments employing twenty or more women or minors, may be adopted as representing a good first-aid outfit: —

One 2 oz. Bottle of Aromatic Spirits of Ammonia (to be renewed every 3 months).
DOSE — ½ to 1 teaspoonful in medicine glass of water.
INDICATIONS — *Sudden Heart Failure*, give internally.
— *Fainting*, pour small quantity on handkerchief and inhale, and give internally.
Headache, rub on forehead.
One 2 oz. Bottle 4% Boric Acid Solution.
INDICATIONS — *Eye Wash, Burns and Scalds.*
One 2 oz. Bottle Sterilized Castor Oil.
INDICATIONS — *Burns and Scalds.*
One 2 oz. Bottle Alcoholic Iodine.
INDICATIONS — Pour in wound to prevent infection.
Two 3 oz. Tubes 3% Bicarbonate Soda in Petrolatum.
INDICATIONS — *Burns and Scalds.*
One 3 inch by 10 yards, Roll Gauze Bandage.
" 2 " " 10 " " " "
One 1 " " 10 " " " "
One Medicine Glass.
Three Drinking Cups (Paper), to be used once only.
One Teaspoon.
One Eye Dropper.
One Pair 4½-inch Scissors.
One Dozen Assorted Safety Pins.
One 1 oz. Jar Green Soap, to cleanse hands.
One Basin, enameled, or non-rustable metal.
One-half pint grain Alcohol.
INDICATIONS — To disinfect hands.
Six Paraffine envelopes each containing 6 inches by 36 inches Sterilized Gauze, dressings for wounds, burns, etc.
One Yard 24-inch Canton Flannel, to make triangular slings.
One 1 inch by 5 yards Spool Adhesive Plaster.
One Rubber Tourniquet, 24 inches by ½ inch, or of Webbing about 24 inches by 1 inch, to control hemorrhage.
Two Splints, 30 inches by 4 inches by 3/16 inch, Whitewood, and One Wire Gauze Splint, about 30 inches by 4 inches, for fractures.

For establishments doing hand work only, light contracting work and similar service, where a standard first-aid kit is not required by law, it is recommended that outfits containing at least the following items from the above-mentioned list be provided: —

Bottle of Alcoholic Iodine.
Tube of Bicarbonate of Soda in Petrolatum.
Roll Gauze Bandages in assorted widths.

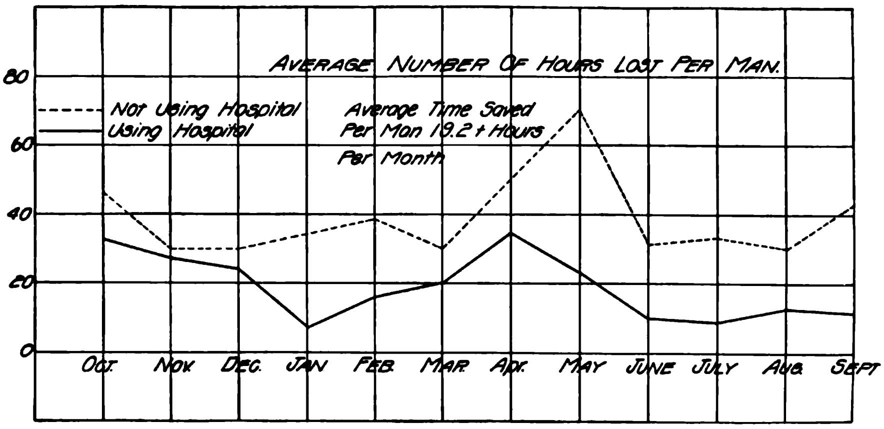


Fig. 1. Chart showing Value of Plant Hospital in reducing Lost Time. (Norton Co.)

The chart shown in Fig. 1 indicates that considerable time can be saved through careful medical supervision of employees. Such supervision makes it possible to minimize machine shutdowns and consequent loss of product, through illness or poor physical condition of the employees.

A thorough physical examination of all workmen (Fig. 2) is advantageous for both employer and employee; without such examination a man may be placed at work which is extra-hazardous for him, on account of some unknown physical defect.

Fig. 2. Physical Examination of Employee.*

The First-Aid Kit illustrated in Fig. 3 has been developed by the National Affiliated Safety Organizations. (See Page 404.) It is compact, convenient, and effective.

The glass container permits the desired article to be quickly located. A wooden box is provided for protecting the glass container.

The First-Aid Kit shown in Fig. 4 is a standard commercial article. It is put up in a metal carrying case.

Fig. 3. First-Aid Kit.

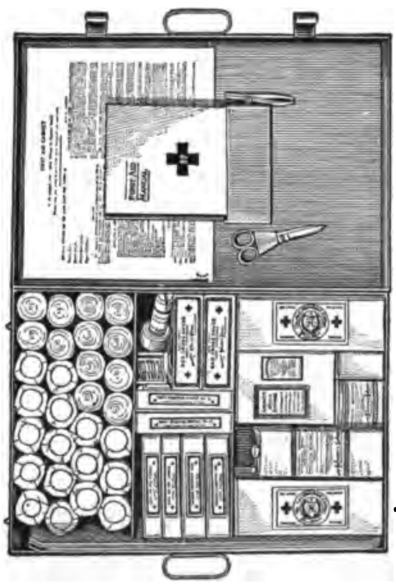


Fig. 4. First-Aid Kit.

*** Courtesy of American Steel Foundries Company.**

Where there is likelihood of getting particles of dust in the eyes, a bottle of Boric Acid Solution and Eye Dropper may be added.

DIRECTIONS FOR FIRST-AID TREATMENT

Abrasions

Whenever the skin is scratched or broken by any small cut or abrasion, the injury should be treated with alcoholic iodine and bandaged, in order to avoid danger from infection. Washing is not recommended unless to remove superficial dirt. Soap should not be used in washing injuries to which iodine is to be applied. (Grain alcohol or gasoline may be used for this purpose.)

Bleeding

When a wound is bleeding, as a rule if the blood is coming from an artery it is bright red in color and comes in spurts. When it comes from a wounded vein it is much darker in color and flows steadily from the wound. Until the proper instruments can be obtained or until the doctor can be called, pressure should be applied to the wound with a pad of surgical gauze, or if the gauze is not available, with a clean hand. If the hemorrhage is excessive and pressure of the wound does not stop it, a tourniquet (which may consist of a handkerchief or a piece of string or rope) should be tied wherever possible between the wound and the heart. The only exception to this rule is when the blood is coming entirely from a vein, then the tourniquet should be tied on the side of the wound away from the heart.

Bruises

The term "bruise" is applied to a discoloration of the skin due to a collection of blood under the skin outside of the blood vessels. Slight bruises do not need any treatment. If the part is painful it may be well to apply hot cloths to relieve the pain.

Burns and Scalds

Burns and scalds should be protected from the air as quickly as possible. Until suitable oil or other greasy substance (such as castor oil or soda bicarbonate in petrolatum, see "first-aid equipment") can be obtained, clean cloths may be applied. Where the latter is available, gauze should be moistened with it and placed over the entire burned surface. The cloths should then be held in place by a loose bandage.

Burns from acid should be quickly washed with plenty of water, then treated as specified in the preceding paragraph.

Burns about the Eyes:

After a chemical burn has been received, the eyes should be bathed immediately with cool water. They should then be covered from the light and a doctor called as soon as possible. It is particularly important to keep the patient in the dark after his eyes have been subjected to an electric flash; severe pain may develop in the course of a few hours, even though no immediate effect is felt.

Cramps

In case of serious cramps, a physician should be called immediately.

Cuts

All cuts should be dressed as soon as possible after they are received. If they are fairly superficial, pressing the cut edges will generally stop the bleeding. As soon as possible they should be washed, gently, with grain alcohol, gasolene or clean water (without soap) and iodine applied. A person dressing a wound should be careful to first wash his own hands.

Dislocations

Dislocations of fingers may be treated by merely pulling the injured finger until the joint goes back into place, and then bandaging it. In case limbs are dislocated the patient should be kept quiet until a doctor can be called.

Electric Shock

For treating cases of electric shock, the "Prone Pressure" method of resuscitation is recommended. (See Page 391.) This is also used successfully for drowning accidents, asphyxiation, etc.

Eye, — Particles In

If the particle can be seen easily and is not imbedded in the substance of the eye itself, it can generally be wiped out by a small swab of absorbent cotton or the corner of a clean pocket handkerchief. It may be necessary to turn up the upper lid in order to see the particle. If the latter cannot be removed easily it is much better to cover the eye with a light bandage until the surgeon arrives.

Fainting

When a person faints, put his head as low as possible. If not convenient for him to lie down, put his feet up on a chair and his head on the floor. When partially recovered it may be well to give him a half teaspoonful of aromatic spirits of ammonia in half a glass of water.

Fractures

When a fracture is suspected, the injured limb or part should be kept as quiet as possible until a doctor can be called. It is not always wise to remove the clothing as the fragments may be disturbed and add still greater damage to the soft tissues. In case of a fractured leg, it is well to tie the two legs together until proper splints may be applied by the surgeon. In case of a fractured arm, strap the arms lightly to the side. The principal thing is to keep the injured part as quiet as possible.

Infection

Infection of a wound is due to some foreign element getting into it. Crushed wounds are more apt to become infected than clean-cut ones. Unless one has at hand the proper materials for dressing a fresh wound it is much better to simply make application of hot water with clean cloths. The real dressing of the wound should be delayed until the surgeon arrives. (See also "Abrasions.")

Poisoning

If a poisonous substance has been swallowed the doctor should be sent for immediately. While waiting for the doctor the patient should drink quantities of water, preferably warm, and should be made to vomit.

Shock

This is a condition which may follow any accident no matter how trivial. It is best treated by first stopping the hemorrhage, if there is any, according to the directions already given. The injured person should be placed in a horizontal position with no pillow under the head. If sufficiently conscious, a half teaspoonful of aromatic spirits of ammonia should be given with a medicine glass of water. If the injured person is cold and pale, hot water, cloths or hot water bottles should be applied whenever possible. Care should be taken not to burn the patient by putting on hot applications or by putting the hot water bottle too close to the skin.

Sprains

A sprain is a wrenching or tearing of the structures about a joint. If it is a sprained ankle the injured person should not put his weight on it. A general rule is to keep all sprained parts at rest as much as possible until proper medical attendance is at hand.

CHAPTER 51

RESUSCITATION

INJURIES may be received in any industry, that will cause suspended animation; this may come from nervous disturbance following a blow, electric shock, or even severe fright, resulting in interference with breathing, with the heart action, or both. It may also be caused by suffocation, or shutting off the supply of oxygen, as in drowning or breathing noxious vapors such as illuminating gas, ammonia fumes, smoke, sewer gas, etc.

It has been demonstrated, however, that this interference with the natural functions is not necessarily fatal; if these functions can be re-established artificially and carried on by an external agency until the system recovers from the initial shock, the normal action will be resumed. Serious effects may thus be avoided where injuries would otherwise quickly result in death.

Such injuries, however, produce an acute crisis, calling for quick action if the life is to be saved, and might be compared to immersing the person's head in a pool of water; the question of life or death is all decided in a few minutes. The conditions under which industrial work is carried on are often such that any efforts at resuscitation, if they are to be effective, must be made by a fellow-worker, at least until a physician can be called.

There are two methods of resuscitation, (1) manual, which may be applied by any person of ordinary ability without the use of any tools or equipment; (2) mechanical, which requires some type of "breathing" apparatus.

MANUAL RESUSCITATION

Sylvester Method

Almost every one is familiar with the so-called "Sylvester" method, for reviving persons who have been drowned; in this, the victim is placed on his back and the arms are raised and lowered rhythmically. This plan is now being replaced, however, by one which is superior in several respects, called the "Prone Pressure" method.

The Prone Pressure, or Shaefer Method of Resuscitation, introduced in the United States in 1908, has been rapidly gaining recognition, and many lives have been saved through its use. Several cases of this kind, involving circuits of 6,000 to 13,000 volts, are described by Dr. Charles A. Lauffer, Medical Director of the Westinghouse Electric Company in "The Electric Journal," December, 1913. (See also Chapter 13.)

In a further case of which the author has knowledge, a sub-station foreman came in contact with a lightning arrester attached to a 30,000 volt transmission line; as he was holding iron rods forming a part of the roof truss, a good ground connection was formed and the contact lasted for several minutes. It was necessary for some one to go on the roof and short-circuit the transmission line before the injured man could be removed. Although burned so badly as to necessitate the amputation of both fore-arms and the removal of a part of one heel, this man fully recovered.

These and many similar examples which might be cited show conclusively that contact with an electrical conductor, even though it be of high voltage, is not necessarily fatal, if proper treatment is immediately applied. At first death is only apparent — not real.

A point which should be recognized in this connection is that even a physician may pronounce the victim of an electric shock dead, under a misapprehension of the real conditions or from lack of experience with this particular form of casualty, which is comparatively rare. In the annual report of the Chief Inspector of Factories and Workshops, of Great Britain, for

1912 (page 194) the Chief Electrical Inspector cites a case where bystanders continued artificial respiration and succeeded in resuscitating a man who had received an electrical injury, after a physician had examined him and stated that life was extinct. Dr. Lauffer speaks of two similar cases which occurred during the course of a year, on which he gives the following comments:

> It must be remembered that a physician is not necessarily infallible. — The friends of these men had better muscle and more courage than the physicians who pronounced the doleful verdict; and courage plus muscle won out. When a man's comrades know the possibilities of the Prone Pressure method and have confidence in their ability to apply it, you may rely upon it that the victim of accidental electrocution will not perish unassisted before the eyes of his friends.

Two excellent treatises* on the subject of electrical injuries and resuscitation have been prepared by Dr. Lauffer; in these are contained a clear and comprehensive discussion of such subjects as electric flashes and burns and their treatment, criminal electrocutions, theories of electric shock, resuscitation, etc. In connection with the latter subject Dr. Lauffer gives a description of the ***Advantages of the Prone Pressure Method,*** which may be summarized as follows:—

1. It is easy to learn.
2. It requires no apparatus.
3. It can be carried on easily by one person.
4. Spirometer tests show its superiority in the amount of "tidal air" handled.
5. It best meets the requirements of electric shock, because: —
   - (*a*) There is no danger of "swallowing the tongue" which is likely to occur if the patient is laid on the back.
   - (*b*) Blood or secretions (which might otherwise drown the patient) flow naturally from his mouth.
   - (*c*) Pressure on the ribs relieves muscular contraction, which might prevent manipulation of the arms.

It accordingly follows that for industrial service, it is an excellent plan to train all intelligent workmen in the Prone Pressure method, so they will be capable of applying it immediately in case of emergency. This is particularly desirable for linemen and repair gangs, etc., whose work may take them far out of reach of prompt medical attention; also for men subjected to any hazard from electricity, gas, drowning, etc.

* "Electrical Injuries," John Wiley & Sons, 1912, and "Resuscitation," John Wiley & Sons, 1913.

Manner of Applying the Prone Pressure Method

A commission representing the American Medical Association, the American Institute of Electrical Engineers and The National Electric Light Association has approved the Prone Pressure method of resuscitation, and has recommended the rules given below for applying it. While this commission considered it particularly for use in connection with electric shock, the point should not be lost sight of that the Prone Pressure method is equally favorable for drowning, asphyxiation, and any other cases where suspended animation occurs.† The rules and illustrations for using this method were issued by the N.E.L.A. in the form of bulletins approximately the size of this page, arranged as follows: —

Rules Recommended by Commission on

RESUSCITATION FROM ELECTRIC SHOCK

Representing The American Medical Association, The National Electric Light Association, The American Institute of Electrical Engineers

(Copyright, 1912, by The National Electric Light Association, and reprinted by their permission)

FOLLOW THESE INSTRUCTIONS EVEN IF VICTIM APPEARS DEAD

I. Immediately Break the Circuit

With a single quick motion, free the victim from the current. Use any **dry** non-conductor (clothing, rope, board) to move either the victim or the wire. Beware of using metal or any moist material. While freeing the victim from the live conductor have every effort also made to shut off the current quickly.

II. Instantly Attend to the Victim's Breathing

1. As soon as the victim is clear of the conductor, rapidly feel with your finger in his mouth and throat and remove any foreign body (tobacco, false teeth, etc.). Then **begin artificial respiration at once.** Do not stop to loosen the victim's clothing now; **every moment of delay is serious.** Proceed as follows:

(*a*) Lay the subject on his belly, with arms extended as straight forward as possible and with face to one side, so that nose and mouth are free for breathing (see Fig. 1). Let an assistant draw forward the subject's tongue.

† A committee on "Resuscitation from Mine Gases" has since rendered a similarly favorable report to that of the commission on Electric Shock.

FIG. 1—INSPIRATION; PRESSURE OFF.

FIG. 2—EXPIRATION; PRESSURE ON.

(*b*) Kneel straddling the subject's thighs, and facing his head; rest the palms of your hands on the loins (on the muscles of the small of the back), with fingers spread over the lowest ribs, as in Figure 1.

(*c*) With arms held straight, swing forward slowly, so that the weight of your body is gradually, but **not violently,** brought to bear upon the subject (see Fig. 2). This act should take from two to three seconds.

(*d*) Then immediately swing backward so as to remove the pressure, thus returning to the position shown in Figure 1.

(*e*) Repeat deliberately twelve to fifteen times a minute the swinging forward and back — a complete respiration in four or five seconds.

(*f*) As soon as this artificial respiration has been started, and while it is being continued, an assistant should loosen any tight clothing about the subject's neck, chest, or waist.

2. Continue the artificial respiration (if necessary, two hours, or longer), **without interruption**, until natural breathing is restored, or until a physician arrives. If natural breathing stops after being restored, use artificial respiration again.
3. **Do not give any liquid by mouth until the subject is fully conscious.**
4. Give the subject fresh air, but keep him warm.

III. Send for Nearest Doctor as Soon as Accident is Discovered

Nearest Doctor and Hospital:

Name	Address	Telephone
....	....	....
....	....	....
....	....	....

Dr. Lauffer, in the book already referred to, brings out various additional points which are of value by way of amplification of these rules, and which are worthy of careful study by those interested.

Forethought

It is most important that definite provisions be made before an emergency arises, so there will be no loss of time and no uncertainty as to what shall be done when an accident occurs.

There is no doubt but that in many instances human lives have been thrown away simply from the lack of adequate forethought in preparing a definite plan of action in advance. (See "Drilling Employees," P. 124.)

This is important not only as regards the application of resuscitation, but in planning the rescue work as well. The location of switches and means for short-circuiting or grounding the lines should be kept clearly in mind at all times. No one should be sent onto an elevated structure or into an underground pit or manhole where electric shock may be received, without adequate provision being made for removing him to a place of safety in case he should be injured. Where necessary this provision should include suitable ropes, tackle, ladders, etc. (See Fig. 3, P. 277.)

MECHANICAL RESUSCITATION

Various types of equipment have been devised for use in cases of suspended animation. Among these might be mentioned apparatus for electric excitation, and an arrangement for mechanically manipulating the arms of the patient by which this operation becomes less laborious.

The devices most commonly used, however, are the Pulmotor, and the Lungmotor. (See Page 393.) In applying the former a mouthpiece is placed over the nose and mouth of the injured person, and pressure and vacuum are produced alternately by means of oxygen escaping from a high-pressure cylinder. This is regulated by an automatic valve so that the change between inhalation and exhalation takes place as soon as a certain pressure or vacuum has been established.

In the Lungmotor the inflation and deflation of the lungs are accomplished by means of a hand pump, so its operation is independent of the oxygen supply. Oxygen can be used if desired, however, and the arrangement is such

Fig. 1. Pulmotor.*

Fig. 2. Oxygen Respirator.*

Fig. 3. Lungmotor in Case.

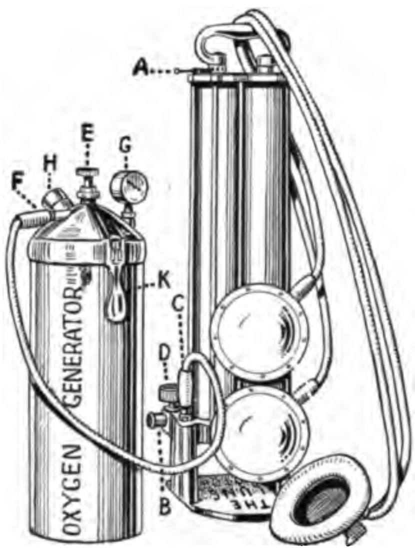


Fig. 4. Lungmotor.

The illustrations on this page show apparatus for administering oxygen in cases of suspended animation.

Figs. 1, 3 and 4 represent appliances for mechanically inflating and deflating the lungs.

In the case of the pulmotor, the proportion of oxygen to air is fixed; in the lungmotor this can be varied from pure oxygen to pure air.

Such apparatus should only be used under the immediate direction of a physician or some one thoroughly skilled in handling it; for purely emergency service the Prone Pressure method of resuscitation is best, and it should be started immediately without waiting for oxygen apparatus to be procured.

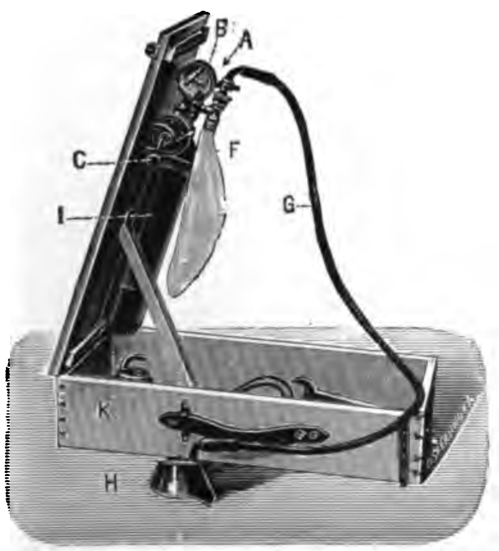


Fig. 5. Oxygen Trunk.

Figs. 2 and 5 show a simple form of equipment for administering oxygen, where the victim is still breathing, or in conjunction with manual respiration. Oxygen passes from the cylinder through the economizing bag to the inhalator, which is held over the mouth and nose of the injured person. All oxygen cylinders should be provided with permanent pressure gages to indicate that they are properly filled.

* Courtesy American Steel and Wire Company, subsidiary of United States Steel Corporation.

that pure oxygen, pure air, or a mixture of oxygen and air may be obtained. Since the action is controlled entirely by hand, a frequency of some twelve or fifteen changes per minute, or the normal breathing rate, can be secured.

Any mechanical apparatus has the disadvantage of seldom or never being at the place where an accident occurs. While oxygen may be of some value (particularly in cases of gas poisoning), artificial respiration is ordinarily all that is needed, and this should be started immediately. If oxygen should be promptly available after an accident occurs, it may be used by simply permitting it to escape from a tube held close to the patient's nose, while respiration by means of the Prone Pressure method is being carried on.

If mechanical equipment is used it had better be at the direction of a surgeon or some one thoroughly skilled in handling it, — otherwise laceration of the lung tissue or other unfortunate results may be experienced. (See "Report of the Commission on Resuscitation from Electric Shock" of the National Electric Light Association, 1913.)

CHAPTER 52

OCCUPATIONAL DISEASES

WHILE occupational diseases are quite distinct from industrial accidents, in the common meaning of the latter term, there is a tendency to bring injuries from occupational diseases under the scope of the Workmen's Compensation Acts; from this, as well as from the humanitarian standpoint, it is desirable for the safety inspector to be on the lookout for such hazards. Furthermore, genuine accidents may occur as a result of persons becoming nauseated or faint from the effect of industrial poisons.

COMMON OCCUPATIONAL DISEASES

The British factory inspection reports show the following record of industrial or occupational diseases for the years, 1911–1913 inc.

DISEASE	*ALL CASES FOR YEAR*			*FATALITIES FOR YEAR*		
	1911	*1912*	*1913*	*1911*	*1912*	*1913*
Lead Poisoning	669	587	535	37	44	27
Mercury Poisoning....	12	17	14	0	0	0
Phosphorus Poisoning	0	0	0	0	0	0
Arsenic Poisoning	10	5	6	1	0	0
Anthrax	64	47	70	11	6	7
Total	755	656	625	49	50	34

It will be noted that lead poisoning has much the greatest representation in the above list, and it is also the most common occupational disease in this country.

Mercury poisoning is found principally in a few isolated trades such as barometer and thermometer making and the fur industry. Arsenic occurs in some paints, colors, etc. Anthrax is usually contracted from handling infected wool, horsehair, hides or skins (the principal danger arising from materials imported from the Far East).

Occupational diseases may result from handling poisonous metals, from the inhalation of dusts, gases or fumes, from contact with poisonous liquids, etc. In general, such diseases may be guarded against by reducing to the minimum the inhalation of dust and the direct handling of, or contact with, poisonous substances. Important aids to this end are ventilation, mechanical handling, enclosure of apparatus and isolation of dangerous processes. It should be ascertained, by physical examinations, that new employees are in good physical condition and that all employees are keeping in such condition. Personal cleanliness, frequent washing, etc., are also material factors on the side of safety.

An excellent treatise on this subject, which gives an exhaustive discussion of the history of occupational diseases, their classification, remedial measures to be adopted, etc., is "The Occupational Diseases" by W. Gilman Thompson, M.D. (See P. 405.) Dr. Thompson mentions various other forms of occupational diseases in addition to these given above, including the following: — Poisoning by nitro derivatives of benzine (dinitro-benzol, anilin and others), carbon disulphid, nitrous fumes, nickel carbonyl; crome ulceration; eczema; compressed air illness, etc. No general discussion of these subjects will be attempted here. For full details reference may be made to Dr. Thompson's book which contains some seven hundred pages and more than one hundred illustrations.

Since lead poisoning is so common, however, the following additional comments and suggestions on this form of occupational disease are included.

Lead poisoning may be encountered in such industries as the following, — lead smelting or working in any form, plumbing and soldering, printing, tinning or galvanizing of metals, vitreous enamelling (where lead glazes are used), electric storage batteries and the manufacturing and use of lead paints, sandpapering of paint, etc.

Symptoms of Lead Poisoning

Lead poisoning may be acute or chronic. The chief symptoms of acute lead poisoning are: loss of appetite, headache, foul breath, indigestion, constipation, and severe pain in the stomach (abdomen). Some of the symptoms of chronic lead poisoning are: paleness of the skin, headache, loss of appetite, indigestion, constipation, pains and aches in the muscles and joints, paralysis of wrists or feet, and convulsions and unconsciousness; but there are many other bad effects.

Preventive Measures

Where the material handled is a lead product, it is desirable to use it so far as practicable, in moist, rather than in dry form, as this reduces the danger of dust inhalation. Where the molten metal is encountered, care should be taken to avoid inhaling the fumes, or dust which is formed on the top of the bath by oxidization. Even handling of lead in the metallic form may prove dangerous.

The following safety requirements should be carried out:

a. Adequate exhaust hoods should be provided for direct removal of floating dust that contains lead products, also for direct removal of fumes or vapors from molten baths containing lead products.

b. Exhaust systems should be installed, so arranged that draft will be unaffected by direction of wind or other air currents, through the use of suitable monitors, or if necessary, power driven fans.

c. Floors, workbenches, shelving, etc., that become contaminated by lead products, should be cleaned daily by either a moist or a vacuum process. Such surfaces should be smooth, and painted or finished in a manner which will permit of adequate cleansing by these methods; walls should be so finished to a height of not less than 6′ 6″. Sweeping, in a manner which stirs up the dust, should not be permitted. No workrooms in which lead products are treated or stored, should be used for storage of any other materials, or for work unrelated to the lead process.

d. Respirators containing moist sponges and covering both mouth and nostrils, should be worn by all employees exposed to dust containing lead products, in parts of the plant where exhaust systems are not applicable.

e. A lunch room wholly free from contamination of lead products should be provided, and all employees excluded from workrooms containing lead products, except during working hours.

f. Suitable washing facilities, including hot and cold running water, soap and nail brushes, tooth brushes, etc., should be furnished for all employees. (See Fig. 4, P. 399.) (Shower baths are desirable, where it is practicable to furnish them.)

g. Suitable locker facilities should be provided, so that street clothing and working clothing can be separated, to prevent contamination of the street clothing with lead products.

h. Each employee exposed to contact with lead products, should be provided with overalls, aprons or other suitable outer clothing (including head covering where necessary). Such clothing should be washed at least once per week.

i. At the end of each working period, each employee who has been exposed to lead products should remove working clothing (overalls, aprons, etc.), and thoroughly wash hands and face and brush the teeth before leaving the plant or eating.

j. No food, drink or tobacco should be taken into, or used in, workrooms containing lead products. No substances of any nature should be placed by employees in their mouths, while working in such rooms.

k. Each employee exposed to lead products, should receive a medical examination at intervals not exceeding one month. Any employee affected by lead poisoning should be relieved from further exposure to it.

The latter provision is especially important, since persons in excellent health have been known to die within a few weeks from continued exposure to lead poisoning. If careful supervision over the health of the employees is maintained, however, it is usually possible to detect the trouble before it has gone very far, and by a change of occupation, prevent further progress. The familiar blue line on the gums is usually one of the early evidences of lead poisoning.

Bulletins for Lead Workers

A set of rules and other information has been prepared in approximately the following form by the Massachusetts General Hospital, to be printed as bulletins and posted where the workers may see them: —

Advice to Persons Working with Lead or with Lead Paints, etc.

I. KEEP CLEAN! This is of great importance, as particles of lead may stick to anything they touch.
II. WASH YOUR FACE AND HANDS before leaving the shop, and ESPECIALLY before eating.
III. BRUSH YOUR TEETH THOROUGHLY at least once a day.
IV. ALWAYS EAT BEFORE GOING TO WORK. The presence of food in the stomach helps to prevent the lead from getting into the system. Drink plenty of milk.*
V. TAKE PLENTY OF EXERCISE in the fresh air. Walk to and from your working-place if possible.
VI. KEEP YOUR BOWELS OPEN.
VII. EAT YOUR LUNCHEON AWAY FROM WHERE THERE IS ANY LEAD.
VIII. If you eat anything, or chew or smoke tobacco, while at work, you may get lead into your mouth and so into your stomach.
IX. Wear overalls, or a long coat, and some head-covering at your work, taking these things off before going home. These garments should be washed frequently.
X. Drinking alcohol in any form greatly increases the danger of lead poisoning.
XI. Persons working in the dust or fumes of lead should use a respirator to avoid inhaling the poison into the lungs.

* (Author's note.) Some employers have adopted the plan of furnishing milk, free of charge, to employees exposed to lead poisoning.

Lead Poisoning may occur

(*a*) By swallowing tiny particles of lead that have settled on food, or into the mouth in other ways, as from the hands or tobacco.
(*b*) By breathing into the mouth, or into the lungs, tiny particles of lead-dust or fumes from melted lead.
(*c*) By lead being absorbed through the skin, from lead paint on the hands, etc.

Precautions for Printers

I. Remember pig-lead used in linotyping is softer than lead of type. Handle it as little as possible.
II. Drop pig-lead carefully into melting pot. Splashings of molten lead dry and become lead dust.
III. Do not shake crucible in order to blend molten lead better. It will blend of itself.
IV. Plungers on linotype machines should never be cleaned in the workroom. Clean them in boxes in the open air.
V. Avoid lead dust, as much as possible, when trimming and mitreing, or when sawing and routing. Wear a respirator when routing.
VI. Graphite used for lubricating is not poisonous, but all dust is irritating to the lungs.
VII. Lead dust in type cases should be removed in the open air, or by means of a vacuum cleaner. Type cases should fit closely on the floor, or have legs high enough to brush under.
VIII. Benzine and lye are skin irritants. Wear gloves when cleaning type with them, and carefully wash the benzine and lye from the type.
IX. Never put type in the mouth, or moisten the fingers to get better hold of type.

See also Bulletins of the U.S. Department of Labor: —
No. 104, "Lead Poisoning in Potteries, Tile Works, etc."
No. 120, "Hygiene of the Painters' Trade."
No. 127, "Dangers to Workers from Dusts and Fumes, etc."
No. 141, "Lead Poisoning in the Smelting and Refining of Lead."

CHAPTER 53

SANITATION AND WELFARE WORK

THIS line of effort is only indirectly related to that of safety; in some respects it affects the accident record, however, since health and safety go hand-in-hand to a considerable degree. Persons whose vitality is reduced by sickness or disease are more likely to be the victims of accident than those in good health and spirits.

DRINKING WATER

One of the first requisites to good health is plenty of pure, cool, drinking water. This tends to regulate the temperature of the body, so it is of particular value to the mill worker. It also assists in digestion and in eliminating poisons from the system. Drinking water should be cool enough to be palatable, but *not* ice-cold; about 50° F. is a satisfactory temperature.*

The use of the common drinking cup is so well recognized as a medium for spreading disease that it scarcely seems necessary to mention it here; in its place is being substituted the individual drinking cup, usually of waxed or oiled paper, and the bubbling fountain. (See Figs. 1 and 3, P. 399.)

The latter is manufactured in several good designs. The water may run constantly, or it may be controlled by a valve which regulates the height of the bubble at the convenience of the drinker. The arrangement should be such as to make it impossible to touch the spout with the lips while drinking. This can be accomplished by a bowl encircling the spout and extending above it so as to form a guard. There should be a drain connection at the bottom of the bowl, so that the waste will constantly escape.

Where a plant is sufficiently large to justify the expense, it is desirable to have a refrigerating plant from which water can be furnished to a drinking system piped to convenient points throughout the plant. (See Fig. 2, P. 399.) Bubbling fountains may be obtained, however, with an attached cooler in which ice is placed (see Fig. 1, P. 399); this gives good results at a relatively moderate expense, since the fountains can be connected to the ordinary city water supply (provided, of course, that it is of pure quality).

INTOXICANTS

Intoxication has long been recognized as having a direct bearing on the accident problem. It is referred to as a form of "misconduct" on the part of the employee, which annuls his right to compensation, in about half of the workmen's compensation acts passed during the last three years.

A Cause of Accidents

Three of the important death cases which came before the Industrial Accident Board of Massachusetts during its first year were the result of intoxication, — in two instances that of the injured man himself, the other that of a fellow workman.†

Fifty-six additional accidents resulting from intoxication were reported (see Page 10).

Effect upon Injuries

Aside from its direct effect in causing accidents, the excessive use of intoxicants tends to aggravate the injury and prevent proper healing of wounds. A number of cases have come under the observation of the author where persons who had received slight injuries from which they should have recovered speedily, developed acute alcoholism and, as a result of

* See "Drinking Water Supplies," Thomas Darlington, M.D., Bulletin of the American Iron and Steel Institute for June, 1913.

† See "Reports of cases under the Workmen's Compensation Act, determined by Committees of Arbitration, the Industrial Accident Board, and the Supreme Judicial Court, July 1, 1912, to June 30, 1913," pages xi and xix.

Fig. 1.

Fig. 2.*

Fig. 1 illustrates a drinking fountain with individual ice cooler.

Fig. 2 is a photograph of a central refrigerating plant, for cooling the drinking water used throughout a large works of the National Tube Company.

Fig. 3 shows one of the mill fountains supplied by the plant illustrated in Fig. 2; the pipes are lagged to prevent absorption of heat. There is approximately one fountain for every thirty men employed, and about $2\frac{1}{4}$ gallons of water per man are required during warm weather.

Fig. 3.*

Fig. 4.*

Fig. 4 shows a wash room in one of the National Tube Company Mills; note individual basins, metal lockers, shower baths, etc. An attendant is constantly on duty in these rooms to see that they are properly maintained.

* Courtesy of National Tube Company, subsidiary of United States Steel Corporation.

this condition succumbed to their injuries within a few days. In this connection the following comment is of interest: —

My own Hospital — St. Bartholomew's —is close to the Meat Market, and unfortunately a large number of the meat porters are addicted to alcohol, and we have great difficulty to get their wounds to heal properly, because they are infused with alcohol, and because of the condition of their tissues due to alcohol. These cases tend to run a very chronic tedious course, and sometimes even end fatally. One fights shy of having to operate upon patients who are alcoholic, because of the degeneration of their tissues, — they do not heal well, in spite of the asepticism of the present day.*

How intoxication may be reduced

It accordingly follows that it is well for the employer to give this matter serious consideration in selecting new workmen. By way of practical suggestions for handling the matter among those already employed, the following paragraphs from an article in a bulletin of the American Museum of Safety for May, 1914, by Norman E. Ditman, M.D., are worthy of attention: —

The alcohol problem always has been, and always will be, a delicate one. We realize that the danger from alcohol is in its abuse; also that the finer the character of work we demand of our employees, the smaller becomes the amount of drinking which constitutes abuse. Moreover, those of us who sin are hesitant about "casting the first stone" when it comes to forbidding others to drink. There are two modes of procedure, however, which are open to any large employer of labor, whether he himself is perfect or not: —

First, — to encourage moderate drinking (only) or abstinence, after working hours, by educational means; and, second, — to demand abstinence during working hours by virtue of his right to obtain his money value for his expenditure for labor. It has now been *proven* beyond a doubt that the use of alcoholic drinks impairs the health and the efficiency of the laborer — slows the fingers of the textile operator, dulls the mind of the financial accountant and impairs the discernment and judgment of the railroad engineer.

Almost all our American railways are now actively discouraging the use of alcohol by their employees, many forbidding its use during working hours, and others placing a ban on its use at any time — especially on the part of their skilled operatives of whom the engineer is the chief example.

Other industrial concerns outside the railroad world have begun to recognize the advisability of dealing with this problem.

Among the European industrial organizations which prohibit the use of alcohol during working hours are the Krupp Company, the Hamburg-American Line, Fried. Bayer & Company, the Continental Rubber Company, the Saxon State Railways, the Trade Association of the Chemical Industries and the Printers' Trade Association in Germany.

Many other organizations advocate and encourage temperance, among which may be mentioned the Dutch, Swiss and Baden Railways, the Berlin City Gas Works, the Imperial Canal Office at Kiel, Ludwig Loewe & Company, and the Allgemeine Elektricitaets Gesellschaft (A. E. G.), of Berlin.

There is considerable uniformity of opinion among the European organizations in regard to the best method of reducing the alcohol consumption among its employees. It is by the method of substitution. They provide canteens in their plants, which furnish tea, coffee, lemonade and water at, or below cost; and they attempt to supplant saloons near the homes of their working men by casinos of an attractive nature where soft drinks are featured.

As a result of this practice in Germany the Allgemeine Elektricitaets Gesellschaft of Berlin reports, that within two years the per capita consumption of alcoholic drinks has diminished about one-third and the consumption of non-alcoholic drinks has increased eight-fold. This company's canteen reports that, while in 1908, 75% of the drinks dispensed were alcoholic and 25% alcohol-free, in 1913 the alcohol-free drinks rose to 80% and only 20% of the sales were drinks containing alcohol.

In the factory of Ludwig Loewe & Co. the daily consumption of beer has been reduced from 2,000 to 200 bottles, while the per capita consumption of tea has become 153 litres a year.

INSTALLATION OF ADEQUATE WASHING FACILITIES

This is an important matter, particularly where there is any hazard from lead poisoning or other occupational diseases. (See "Special Industries" below; see also Chapter 54.) Wash basins should be of individual type. Shower baths are advantageous in foundries, rolling mills, etc., and in any industry where excessive

* W. McAdam Eccles M.S., in "The Alcohol Factor in Social Conditions," George Blaiklock, p. 36.

heat or dust are encountered. (See Fig. 4, P. 399.)

The Massachusetts State Requirements for washing facilities are as follows: —

Where Required and Sex Designation. In every establishment where persons are employed there shall be provided, within reasonable access, a sufficient number of proper washing facilities, and where ten or more males and ten or more females are employed together separate washing facilities shall be provided for each sex, and shall be plainly so designated.

Number Required. The number of wash bowls, sinks or other appliances shall not be less than one to every thirty persons, based upon the maximum number of persons entitled to use the same at any one time. Twenty inches of sink will be considered as an equivalent of one wash bowl.

Special Industries. In special industries or departments where there is undue exposure to poisonous substances or liquids, or where the work is especially dirty, one may be required for every five persons, and in these cases clean, running, hot and cold water shall be provided.

Location. The washing facilities provided must be within reasonable access, as above defined for toilets,* and at least one wash bowl, sink, or other suitable appliances shall be provided in or adjacent to every toilet room.

Lighting. All washing facilities shall be clearly lighted at all times during working hours.

Cleanliness. All washing facilities or appliances, and the floors in and around the same, shall be kept clean, and regular and thorough cleansing shall be practiced.

Miscellaneous. Where common sinks are provided these shall be furnished with individual wash basins.

One tap for each twenty inches of wall sink, or one pair of taps for each twenty inches of double sink, each supplied with clean running water, shall be provided with the sinks.

ADEQUATE TOILET FACILITIES should be provided, located in light, well-ventilated rooms isolated from other rooms. The floors of toilet rooms should preferably be of tile or cement, as this construction is more sanitary than wood and can be easily cleaned. (For good general standards in this connection, see "Rules and Regulations for Toilets in Industrial Establishments" adopted by the Massachusetts State Board of Labor and Industries. See also Bulletin No. 4 of the United States Steel Corporation. The latter standards are somewhat more rigid than the former; for example, the United States Steel Corporation specifies one toilet to every 15 employees, and the Massachusetts Rules one toilet to every 25 employees.)

WELFARE WORK

"Welfare work" is a term commonly used to designate a wide field of activities on behalf of industrial employees. If properly conducted, it can be advantageously combined with safety work as a means of interesting and educating the workmen.

Visiting Nurses. In some cases visiting nurses are employed. They go to the homes of the workmen and offer assistance in case of sickness or misfortune of any sort, teaching laws of hygiene and giving instructions in the preparation of proper food, etc. (See Fig. 2, P. 402.)

Gardening. Where there is ample ground, space may be provided for gardens, thus furnishing a pleasant occupation for the men outside of working hours, at the same time helping out their food supply. The H. C. Frick Coke Company gives prizes to its employees in various locations for the best gardens. (See Fig. 3, P. 402.) In many places flowers and grass plots are now being planted in mill yards which were formerly bare and unsightly. (See Fig. 4, P. 402.)

Club houses containing bowling alleys, billiard rooms, reading rooms, swimming pools, ball rooms, etc., have been provided for the use of the workmen, as well as play-grounds for the children (see Fig. 1, P. 402); also mill restaurants, where wholesome food is furnished at low prices.

Entertainments are used by the United States Steel Corporation as a means of interesting their employees in safety work; moving pictures containing accident lessons are interspersed with those which are merely amusing, and with vaudeville acts, etc.

Educational Work. Most foreign workmen

* "In no case more than three hundred feet distant from the regular place of work of the persons for whose use it is designed, except where service elevators, accessible to the employees, are provided."

Fig. 1. Swimming Pool provided for employees of the H. C. Frick Coke Company

Fig. 2. Nurse employed by Carnegie Steel Company, visiting Employees' Families.

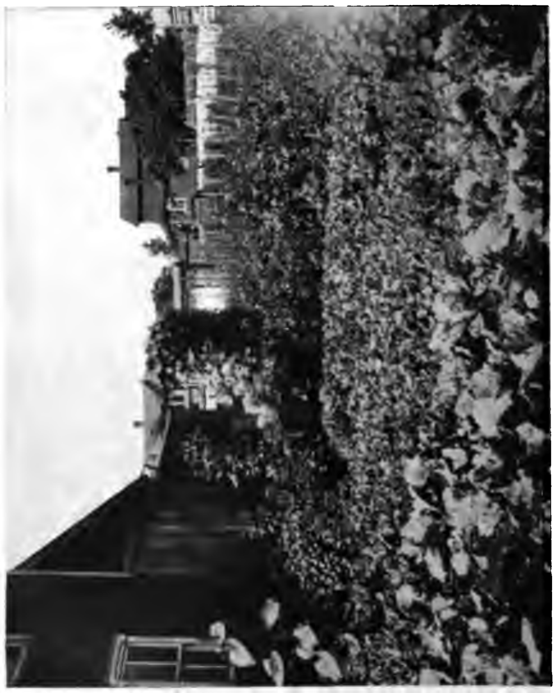


Fig. 3. Employees' Garden, H. C. Frick Coke Company. This company offers cash prizes, to encourage such work.

Fig. 4. Flower Beds and Grass Plots in unused Spots of Mill Yard, — Bethlehem Steel Company.

desire to learn to read and write English, and this has been used as a means of educating them in safety. Safety primers have been prepared, each sentence of which contains a simple phrase, such as a reference to the use of goggles, a warning against cleaning machinery while it is in motion, etc. In this way the men may be genuinely helped in the line of education, and with their first broken words of English comes a knowledge of the doctrine of "Safety first."*

* Some excellent work along this line has been done by the Young Men's Christian Association. See "The Prevention of Accidents," Page 90 of "Foreign-Born Neighbors," Tupper; "The Shoe City Reader," published by The New American Association, Brockton, Mass.; Primer prepared by the Y.M.C.A., Fall River, Mass., on textile machine accidents; "Lessons for Teaching Foreigners English by the Roberts Method," Pages 8 and 9, Bulletin No. 4 of the United States Steel Corporation; etc.

Local journals or news sheets containing pictures of men serving on safety committees. describing accidents, etc., are also helpful.

Profit-sharing schemes for the benefit of their employees are in effect in many plants; the United States Steel Corporation is distributing approximately $1,000,000 per year in this way, aside from the amount spent in providing pensions, and in the relief of its injured and destitute workmen, etc.

All of these plans have been used in various forms. Others might be suggested, but these are sufficient to give a general idea of what may be included in welfare work among employees. (For a well-illustrated description of such activities, see Bulletin. No. 4 of the United States Steel Corporation.)

CHAPTER 54

SAFETY ORGANIZATIONS, PUBLICATIONS, ETC.

THERE are various safety organizations and publications, of value to the safety inspector and others interested in this subject, of which the following is a brief list.

SAFETY ORGANIZATIONS, SOCIETIES, ETC.

National Safety Council

The National Safety Council (Chicago, Ill., Mr. W. H. Cameron, Sec'y), serves as a general clearing house of safety information and sends out weekly distributions of safety literature, including bulletins, statistical information, descriptions of safety practices, rules, etc. It organizes branch Councils, holds an annual safety Congress, has Standardization Committees at work, etc.

NATIONAL AFFILIATED SAFETY ORGANIZATIONS

The National Association of Manufacturers (30 Church Street, N.Y. City), the National Founders Association (29 South La Salle St., Chicago, Ill.), The National Metal Trades Association (Peoples Gas Building, Chicago, Ill.), and the National Electric Light Association (29 West 39th Street, N.Y. City), have a joint "Conference Board on Safety and Sanitation" under the heading of "National Affiliated Safety Organizations," working on the development of safety devices and practices, and the dissemination of information on same through various publications. (Mr. M. W. Alexander, West Lynn, Mass., Sec'y.)

American Museum of Safety

The American Museum of Safety (New York, N.Y., Dr. W. H. Holman, Director) maintains a permanent safety exhibition, gives an Annual Exposition, issues publications at intervals, and assists in public safety campaigns and other lines of safety work.

The National Fire Protection Association (Boston, Mass., Mr. Franklin H. Wentworth, Sec'y.) has a Committee on "Safety to Life" which has been giving attention to the special questions of preventing loss of life by fire. The Association has worked out standards for most of the appliances and processes which have to do with the fire hazard, such as electric wiring and apparatus, storage and use of oils, use of fire doors, wired glass, the installation of automatic sprinklers, tanks, etc., also specifications for hose, pumps, signalling systems and detailed equipment of many kinds.

The Underwriters Laboratories (207 East Ohio Street, Chicago, Ill.), organized to make examinations of fire appliances, electrical fittings, etc., has arranged to extend its field so as to include the testing and approval of safety devices.

SAFETY (AND ACCIDENT) PUBLICATIONS

U.S. Government Publications

A certain number of copies of Government publications are distributed free, after which copies are furnished at cost. Lists may be obtained from the Superintendent of Documents, Washington, D.C.

The Department of Labor (Bureau of Labor Statistics) issues bulletins relating to Workmen's Compensation and Insurance.

The Department of Commerce (Bureau of Standards) has prepared safety rules for the operation and maintenance of electrical equipment and lines.

The Interstate Commerce Commission issues publications describing its safety standards for railway equipment; also bulletins and reports on railway accidents, etc.

The Department of the Interior (Bureau of Mines) issues bulletins and technical papers on the hazards of mining, quarrying, etc.

British Government Publications. Reports on many phases of accident prevention work are issued by the British Government. (Home Office, London, England.) Copies of these reports can be purchased at nominal prices from booksellers such as P. S. King & Son, 2 and 4 Great Smith Street, Westminster, S.W., England.

American Industries. A monthly journal published by the National Association of Manufacturers, 30 Church Street, New York City (see "Organizations"). Each copy contains a section on Accident Prevention and Industrial Insurance.

Safety Engineering. An illustrated monthly magazine, devoted to safety and fire prevention. (80 Maiden Lane, New York City, Franklin Webster, Editor.)

National Compensation Journal. A monthly magazine devoted to Workmen's Compensation, Accident Prevention and kindred subjects. (113 Washington Avenue, Lansing, Michigan: John A. Drake, Publisher.)

BOOKS. (CHRONOLOGICALLY ARRANGED)

The Prevention of Factory Accidents, John Calder. Published, 1899, by Longmans, Green & Co., London and New York. (Now out of print.)

The Prevention of Industrial Accidents, Frank E. Law and William Newell. Published, 1909, by the Fidelity and Casualty Company of New York.

Unfallverhütung und Betriebssicherheit, Dr. Georg Schlesinger. Published, 1910, by Carl Heymanns, Berlin.

Work-accidents and the Law, Crystal Eastman. Published, 1910, by Charities Publication Committee, New York.

Accident Prevention and Relief, Schwedtman and Emery. Published, 1911, by the National Association of Manufacturers, 30 Church Street, New York City.

Woodworking Safeguards, David Van Schaack. Published, 1911, by Ætna Life Insurance Company, Hartford, Conn.

Prevention of Railroad Accidents, George Bradshaw. Published, 1912, by The Norman W. Henley Publishing Company.

Safety, W. H. Tolman. Published, 1913, by Harper and Brothers.

Safeguards for the Prevention of Industrial Accidents, David Van Schaack. Published, 1913, by Ætna Life Insurance Company.

Occupational Diseases, W. Gilman Thompson, M.D. Published, 1914, by D. Appleton & Co.

Universal Safety Standards, Carl M. Hansen. Published, 1914, by The Universal Safety Standards Publishing Company, New York City.

Sure Pop & The Safety Scouts, Roy Rutherford Bailey. Published, 1915, by World Book Company (under the auspices of the National Safety Council).

Safety Engineering applied to Scaffolds, by the Engineering and Inspection Division of the Travelers' Insurance Company. Published, 1915, by Travelers' Insurance Company, Hartford, Conn.

Live Articles on Accident Prevention. Published, 1913–1915, by New York Underwriter Printing & Publishing Company, New York.

Safety in the Foundry, Magnus W. Alexander. Published, 1915, by National Founders Association, Chicago.

THE END

INDEX

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